ASTRONOMY

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The Space Between the Stars

An Interview with Robert Burnham, Jr.

How to Plan a Newtonian Reflector

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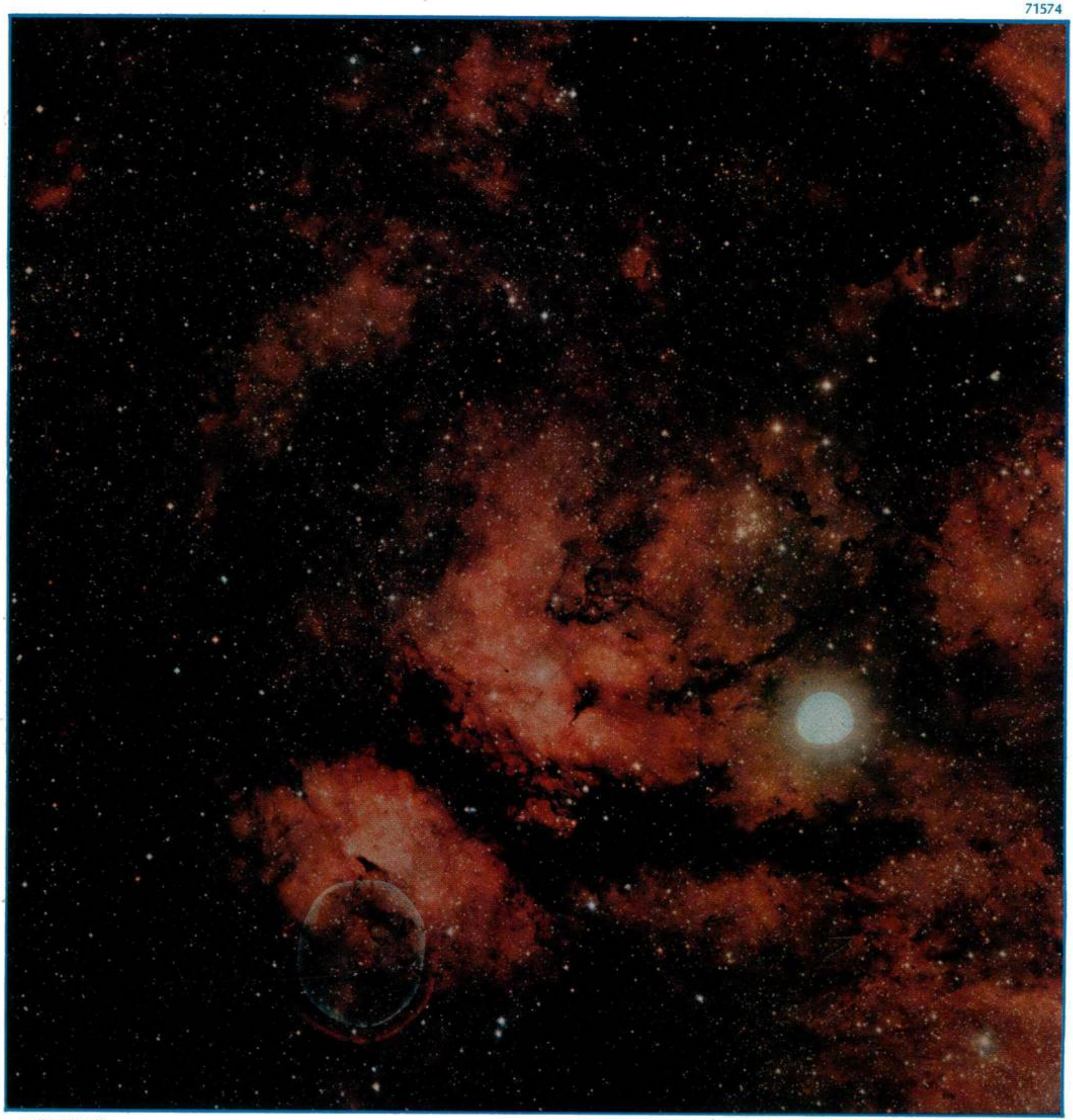

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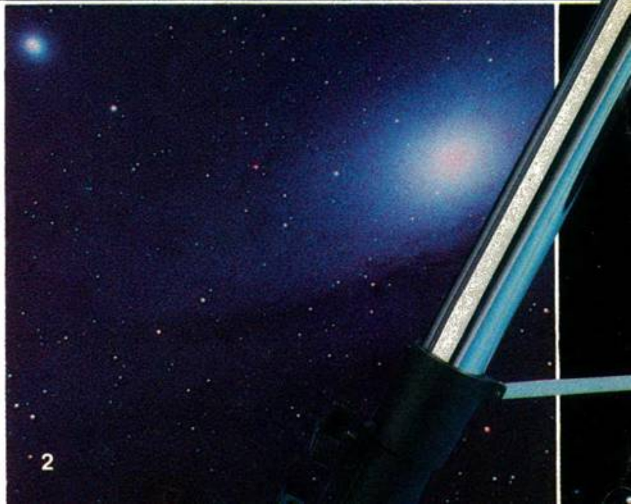
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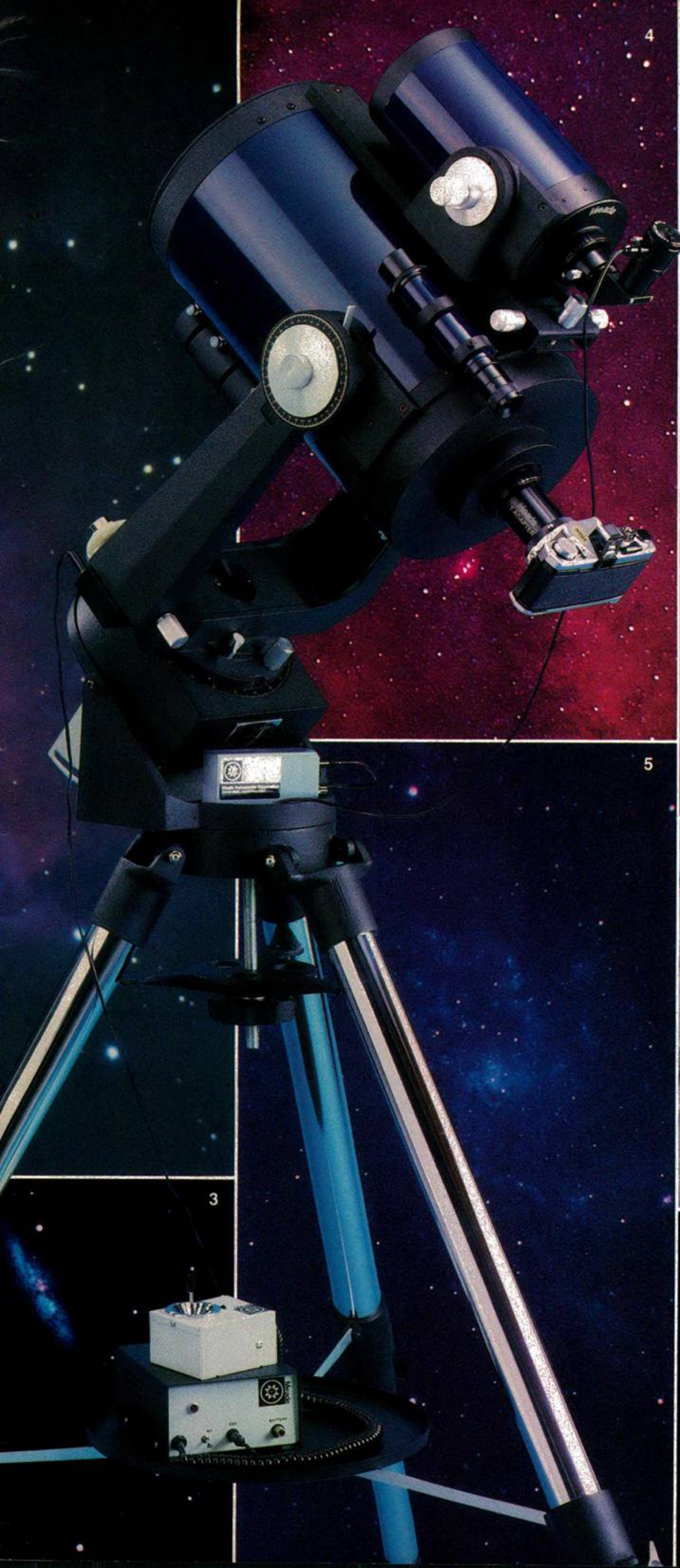

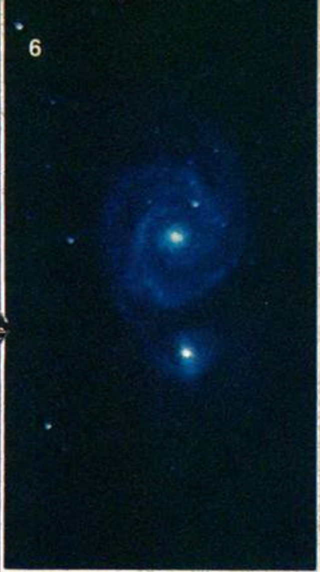

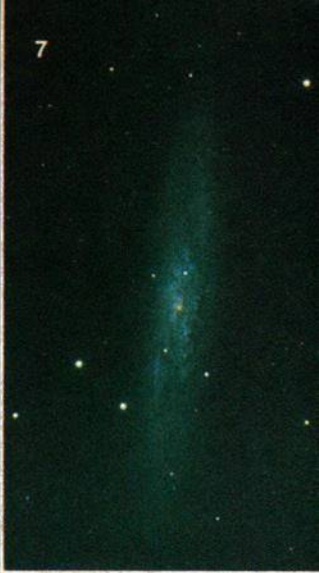

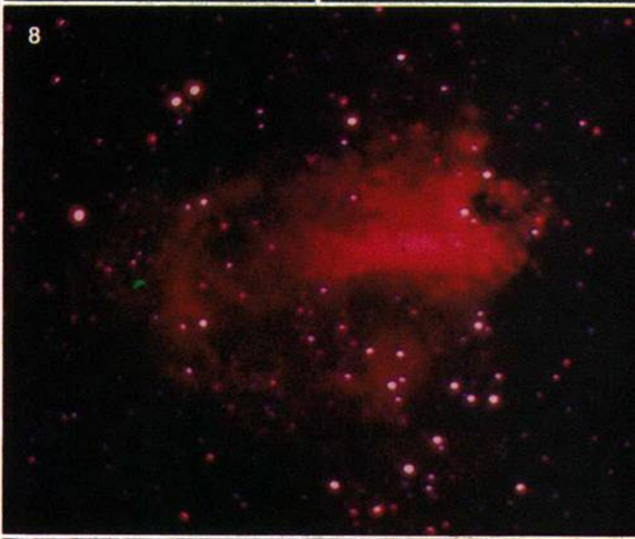

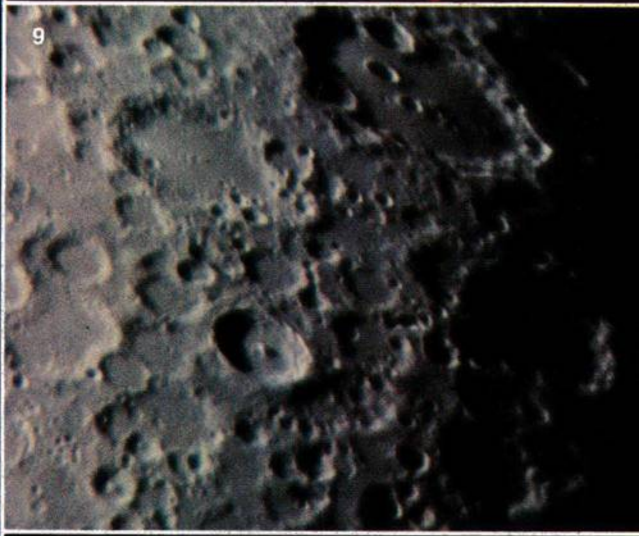

All astrophotographs shown on these pages were taken through off-the-shelf, unmodified Meade 8″ Model 2080 Schmidt-Cassegrain telescopes. For further technical details on these and many other astronomical photographs, send for your free copy of the Meade Schmidt-Cassegrain Astrophoto Brochure. (Alternately, the complete Meade 52-page General Catalog is available at $3.00 by First Class Mail and includes the Astrophoto Brochure at no additional charge.)

Key to Photographs
1, 2, 3, 5, 7 — Leo Henzl; 4, 6, 8 — Emery Hildebrand;
9 — John Sanford

1. Orion Nebula M42; exposure time 50 mins. **2.** Andromeda Galaxy M31; 60 mins. **3.** Galaxy M82; 60 mins. **4.** Milky Way in Sagittarius (50mm piggyback photo). **5.** Spiral Galaxy M33; 75 mins. **6.** Spiral Galaxy M51; 60 mins. **7.** Galaxy NGC 253; 40 mins. **8.** Omega Nebula M17; 40 mins.; **9.** Moon — Clavius region; 1-sec.

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Cover: The region of space around Gamma Cygni abounds with interstellar material — luminous hydrogen gas and dark particles of dust. This month's opening story and Stellar Frontiers explore interstellar material and ponder its vital role in the formation of new stars. Photo © National Geographic Society/Palomar Observatory Sky Survey. These pages: At the end of a star's life, it may explode with a titanic blast that flings much of itself off into space — as the Vela supernova did thousands of years ago. The material will form a new generation of stars. Photo from Steward Observatory.

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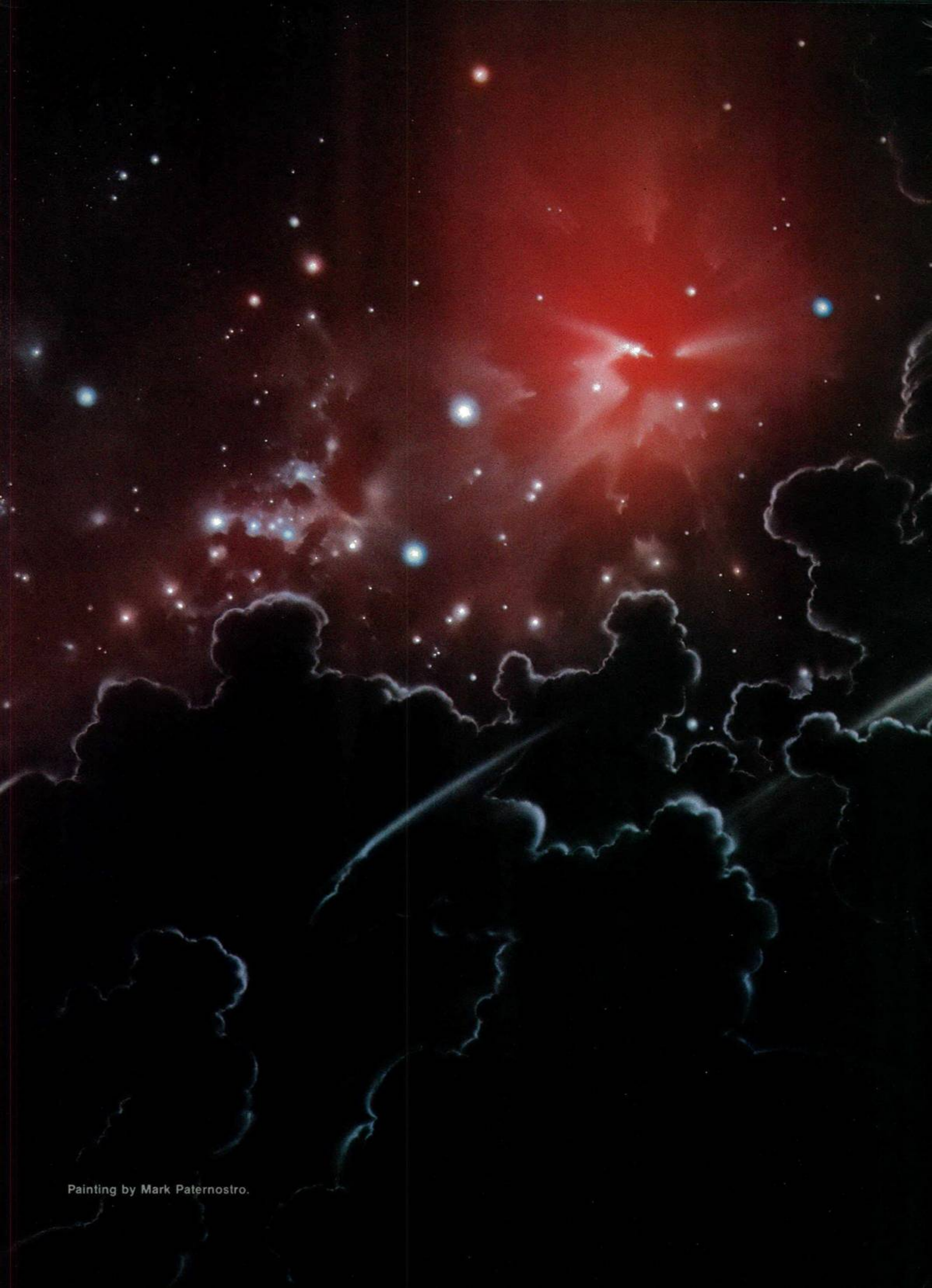

Painting by Mark Paternostro.

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Secrets of Interstellar Clouds

by
Laurence
Marschall

> *. . . But attacking the problem of space with pure thought does not strike me as an occupation on which a man should waste his work and his years. The word "space" means nothing to me and is not worth thinking about unless I can imagine real space, say the space between stars; now studying and measuring star space does not seem an unworthy task to me.*
> — **Hermann Hesse,** *Narcissus and Goldmund*

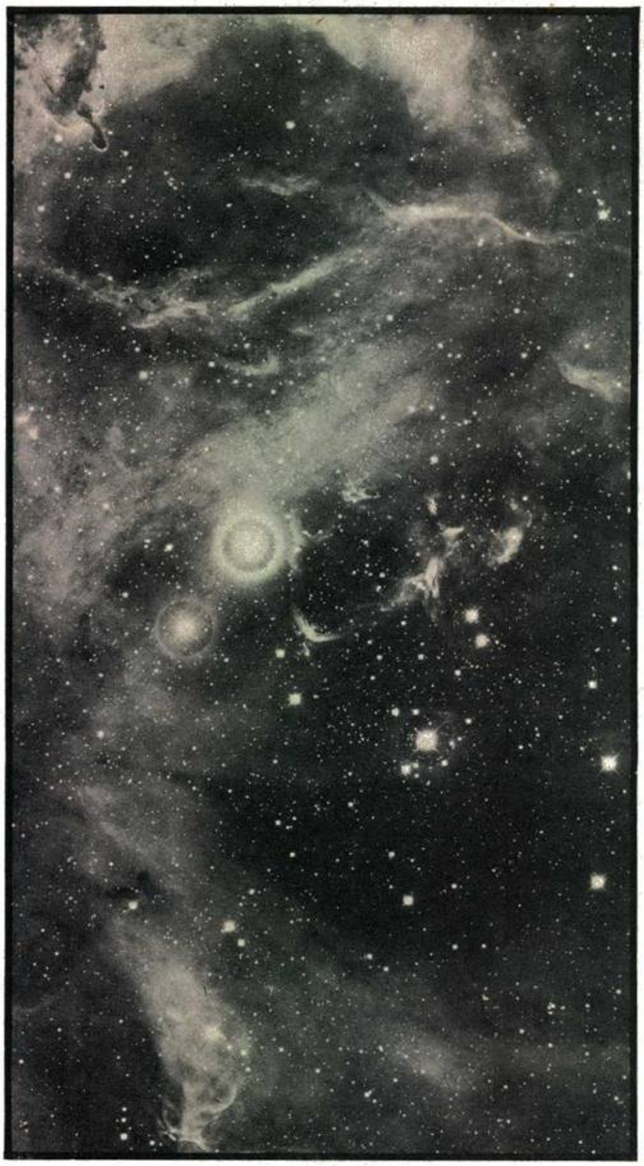
Astronomers are called astronomers — people who study stars — only because of a peculiar quirk of nature. During most of their lives, stars are far hotter than the material that surrounds them and as a result, they glow brilliantly against the black of the night sky. Our inquisitive ancestors studied stars, not the spaces between them, because of this conspicuous glow.

But a surprisingly large portion of the matter in the universe lies not in the "show-off" stars, but in the dark reach of interstellar space that extends around them. In the vicinity of the Sun, for instance, the average distance between the stars — about three-and-a-half light-years — is more than 20 million times greater than the diameter of the Sun itself. Our star, typical of many in the Milky Way Galaxy, occupies a vanishingly small amount of space in the cosmos: something like a dust mote floating in the vastness of the Astrodome.

Modern astronomers, equipped with instruments that probe much farther than the unaided eye, have discovered that interstellar space itself is a vital realm of study. They have found that the space between the stars is far from empty; though it varies greatly from place to place, interstellar space holds an average of one or two gas atoms in each cubic centimeter, as well as occasional solid grains of microscopic size. Although this represents a vacuum almost a million times better than any we can create on Earth, it would add up to an enormous quantity of matter if all the thinly scattered interstellar atoms and particles were gathered together.

But how can we detect this matter, and are there ways to measure it? Where does it lie in the greatest concentrations? What connection, if any, is there between the interstellar matter and stars? Do they share similar chemical compositions? Similar motions? Do they have a common origin in the past? These are the questions that most concern the astronomers who study interstellar space, the researchers who turn their attention from the brilliant stars to the dark spaces between.

In some instances, the interstellar medium is relatively easy to detect. In the vicinity of hot young stars, the interstellar gas glows in fluorescence under the radiation from the stars themselves, much as gas in a neon sign glows in response to the electric current. The Great Nebula in Orion and the Eta Carinae Nebula are two magnificent examples of fluorescent clouds.

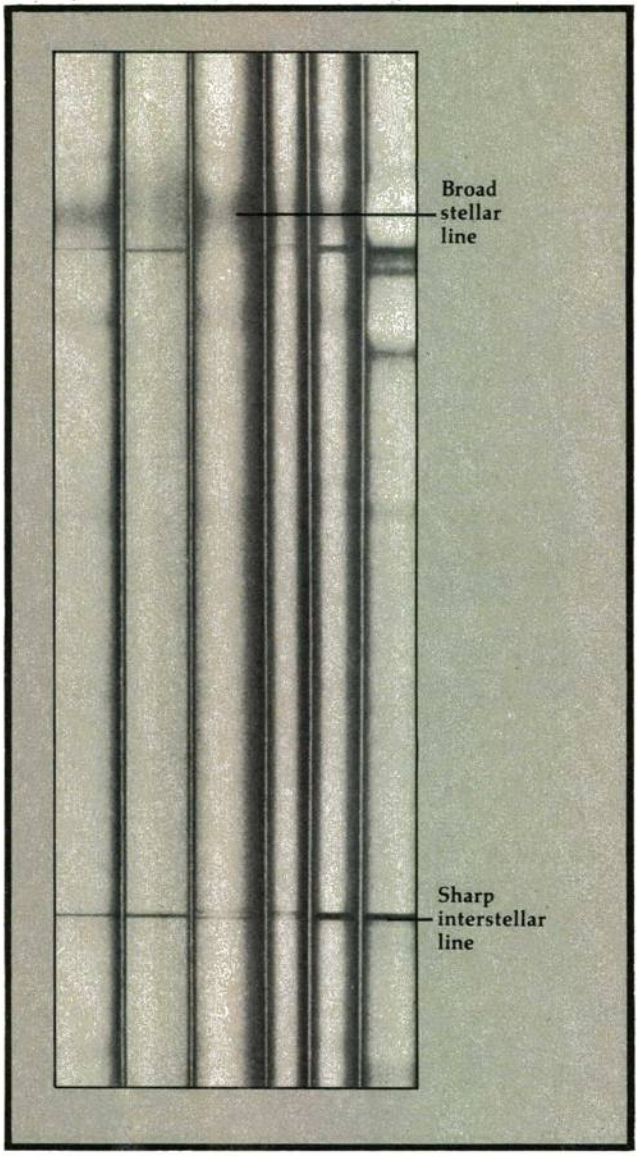


Left: Familiar to most astronomers — armchair, backyard, or professional — the Orion Nebula is a large glowing cloud of ionized hydrogen. But much of the nebula's bulk is invisible, harbored in dark masses of cold molecular material. Photo by Cerro Tololo Inter-American Observatory. Right: Wisps of hydrogen gas, shock waves, and aggregations of young stars abound near the center of the Rosette Nebula in Monoceros. Photo by Kitt Peak National Observatory.

Since the mid-1930s, astronomers have known that most of the gas in these nebulae is positively-charged hydrogen nuclei that have been ionized, or stripped of their electrons, by the energy from the hot stars nearby. Such ionized hydrogen clouds are called *H II regions* to distinguish them from the cooler clouds of darker nonluminous gas — *H I regions* — that are composed predominately of electrically neutral hydrogen atoms and molecules.

Sometimes, those neutral hydrogen clouds can be detected simply because they *don't* glow. If the cloud is dense enough, or has a high concentration of solid grains of dust, it will block out the light from stars and gas clouds that lie beyond. Dark regions show up in several places among the rich star fields of the Milky Way, looking like jagged gaps in the glowing fabric of the sky. They range in size from small globules such as those in the Rosette Nebula to the great Coal Sack that splits the southern Milky Way in the constellation Crux.

Analysis of the darkest clouds indicates that they contain primarily hydrogen molecules. Since direct starlight — even starlight diluted by the immense distances of interstellar space — has enough energy to split up most simple molecules, the molecules can survive only in the dark globules and dense H I



Right: Not all interstellar material is gaseous — the streaks of nebulosity around Merope in the Pleiades are composed of inert dust that reflects the blue light of the hot star. Other stars in the Pleiades also show similar streaky wisps, but little interstellar material remains in the cluster today. Photo by Hale Observatories. Left: Absorption lines of interstellar material are sharper and narrower than the broad lines of stars' atmospheres. Photo by Lick Observatory.

regions, where thick dust clouds block the starlight. Starting with simple hydrogen molecules (where two hydrogen atoms are bound together), more than fifty additional complex species have been detected, including many organic compounds such as alcohol, formaldehyde, and ammonia.

Although they are the most noticeable, neither the bright H II regions nor the dark H I regions are the most abundant manifestations of the interstellar material. Only about 7% of the interstellar gas lies close enough to hot stars to become ionized and glow, and perhaps a similar fraction is dense enough to block the light of more distant background stars. The remainder of interstellar space is transparent to visible light: it's a little startling, but most of these clouds are virtually invisible.

Invisible? Almost, but not quite. The atoms in the thin, diffuse interstellar clouds *do* absorb a bit of light, and if you know just how to search for this missing light, you can not only detect the virtually invisible clouds, but even determine their size, mass, chemical composition, and speed! The key is spectrum analysis.

Stars emit light over a wide range of frequencies, from short wavelength X-rays and ultraviolet waves through the visible and infrared to long-wavelength radio. When starlight passes through a spectroscope and is broken up into its component wavelengths, we see a nearly continuous rainbow band of light that varies in wavelength (color) from one end to the other.

But close inspection of this rainbow reveals dark lines breaking into the apparent continuity of the band. These are the absorption signatures of neutral and ionized atoms in the cooler outer layers of the star. Whenever we see a cooler gas against a hotter source of light, the cool gas will rob certain wavelengths of light from the luminous background source and produce dark lines in its spectrum. The wavelengths of these lines tell us what atoms are present in the cool gas. For instance, neutral hydrogen atoms strongly absorb light at a wavelength of 1215 Angstroms (1 A is 10^{-10} meters), neutral sodium atoms absorb at 5890 A, and singly-ionized calcium atoms (calcium atoms stripped of one elctron) absorb at 3933 A and 3970 A.

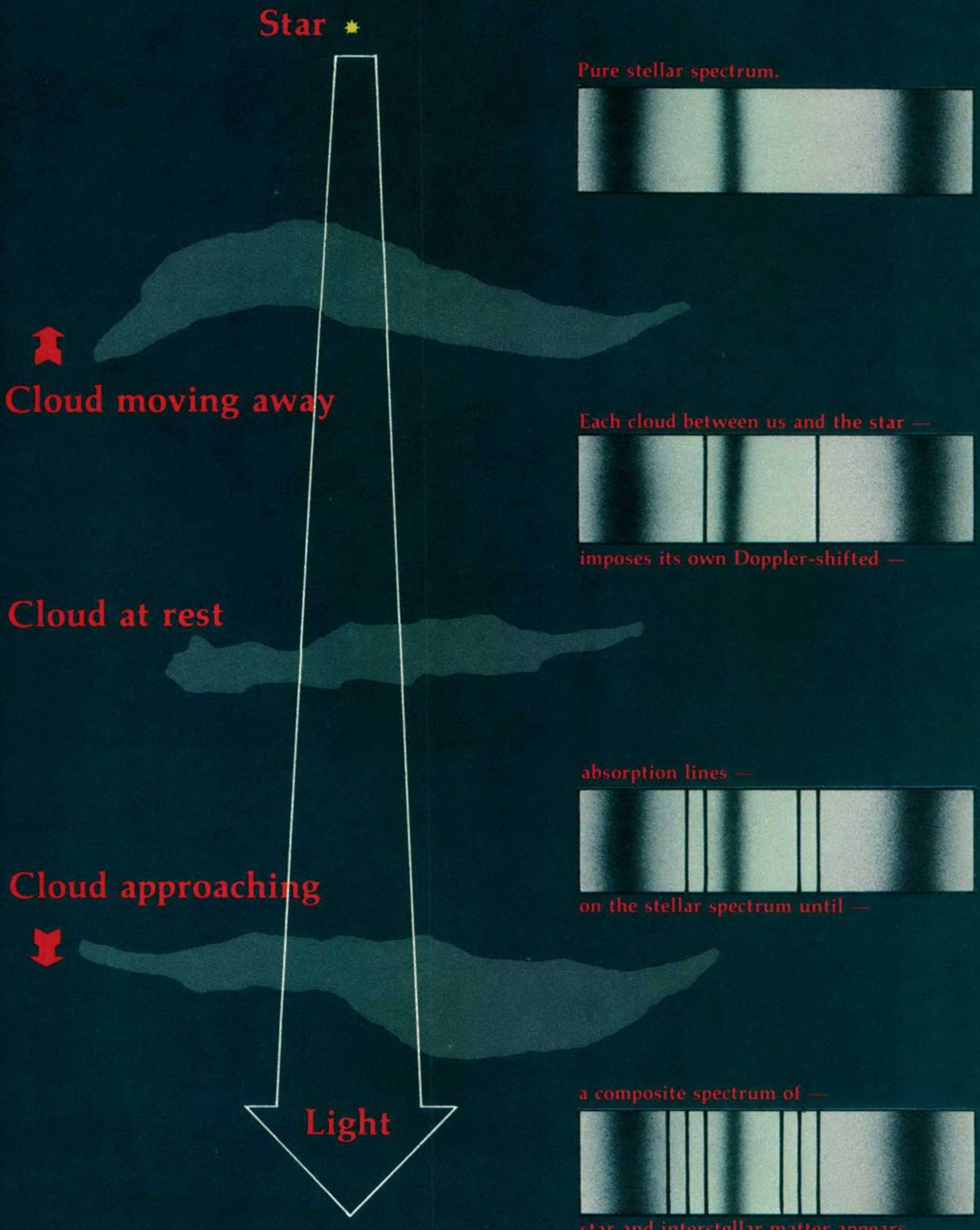
These dark lines in the spectrum of a star tell us the chemical composition of the outer layers of gas in the star — but that's not all. Just as the relatively cool outer layers of a star absorb light from the hotter layers beneath, the even cooler interstellar gas absorbs light from the hotter stars that lie behind it. If an interstellar cloud lay between us and a star, some of the dark absorption lines in the stellar spectrum ought to come from the atoms in the interstellar gas.

Research has uncovered several examples of this. For instance, the spectrum of Alpha Cygni (Deneb), a star 1600 light-years away, has a broad and shallow absorption "dip" caused by calcium atoms in the outer layers of the star's atmosphere. It also shows several narrower and weaker dips that arise from absorption by atoms lying between us and the star — atoms in a thin, almost transparent, interstellar cloud.

How can we distinguish absorption lines in the atmosphere of stars from those of interstellar clouds? If we look at the shape of the absorption features, we find that interstellar lines are generally weaker, narrower, and sharper than the stellar lines. The reason for this is that the interstellar gas is much cooler than the gas of a star. Typical stellar temperatures range from about 2,500 K to about 30,000 K, while most interstellar clouds have temperatures no greater than 100 K.

The hotter a gas is, the faster its particles will move. Atoms in the low-temperature interstellar gas are moving relatively slowly; those in a star's atmosphere are moving far faster. Because of the Doppler shift, atoms traveling toward an observer will absorb light at slightly shorter wavelengths than atoms at rest, and atoms traveling away from an observer will absorb light at slightly longer wavelengths. The greater the speed of the atom, the greater the shift.

This is why the slowly-moving particles in a cool


Star
Pure stellar spectrum.
Cloud moving away
Each cloud between us and the star —
imposes its own Doppler-shifted —
Cloud at rest
absorption lines —
Cloud approaching
on the stellar spectrum until —
a composite spectrum of —
Light
star and interstellar matter appears.

Overleaf left: Cygnus is rich in dusty gas. Photo © National Geographic Society/Palomar Observatory Sky Survey. Left: Individual clouds may impose their own Doppler-shifted spectral signatures on the light from a distant star. Right: The Veil Nebula in Cygnus consists of highly-processed stellar material hurled from an ancient supernova. Photo courtesy of Hale Observatories. Overleaf right: Near Zeta Orionis lie many clouds of gas and dust; seen among them in this negative print is the famous Horsehead Nebula. Photo courtesy of U.K. Schmidt Telescope Unit.

gas produce absorption lines sharper and narrower than those of a high-temperature gas. The high velocities of particles in a hot stellar gas (as well as other effects) create a wide range of Doppler shifts, broadening out the spectral lines in comparison with those from the cooler and more sluggish interstellar clouds.

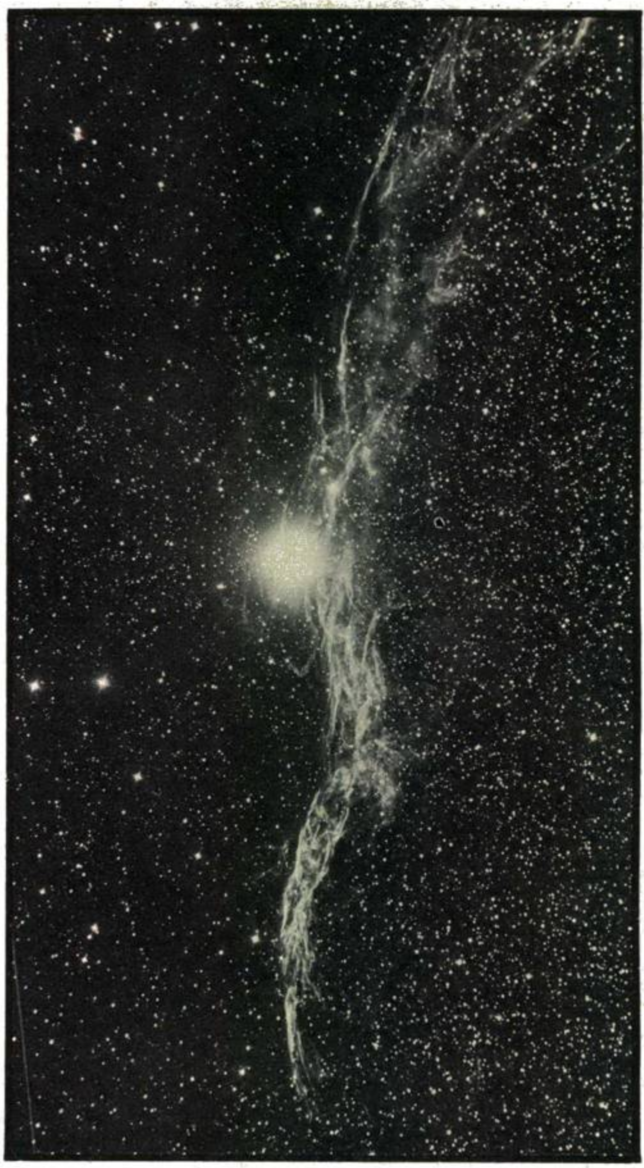
A closer look at the shapes of the interstellar absorption lines reveals further secrets of these invisible clouds and, once again, the Doppler shift provides the clue. In the spectra of many stars, not one but several sharp absorption dips occur — superimposed on the background spectrum. If we imagine that several discrete clouds, each moving at its own velocity, lay in our line of sight to a star, then the absorption lines of each cloud would be Doppler-shifted by the cloud's velocity.

For example, the highly spread-out spectrum of Epsilon Orionis — the central star in Orion's belt — shows several clouds of interstellar gas, each moving at a different velocity and giving rise to individual absorption lines. Not only can we separate stellar from interstellar features, but we can even investigate the motions of individual streams of gas with a spectrograph.

We can make an estimate of how big these clouds are by looking for lines in the spectra of stars that lie close together in the sky. The spectra of several of the bright stars in Orion show features at velocities of 13 and 25 km/sec for nearly all of them. These stars lie in the Orion Association and are about 1500 light-years away from the Sun. If the gas clouds lie approximately halfway between us and the stars, they must stretch for roughly 450 light-years across our line of sight. Whether they are actually a bit closer or a bit farther off doesn't make much difference — these are still very sizeable aggregations of matter.

The total amount of light absorbed by an interstellar line is a measure of the number of atoms present in the cloud. The most abundant chemical elements in stars are hydrogen, helium, carbon, nitrogen, and oxygen. Are these abundant in the interstellar medium as well?

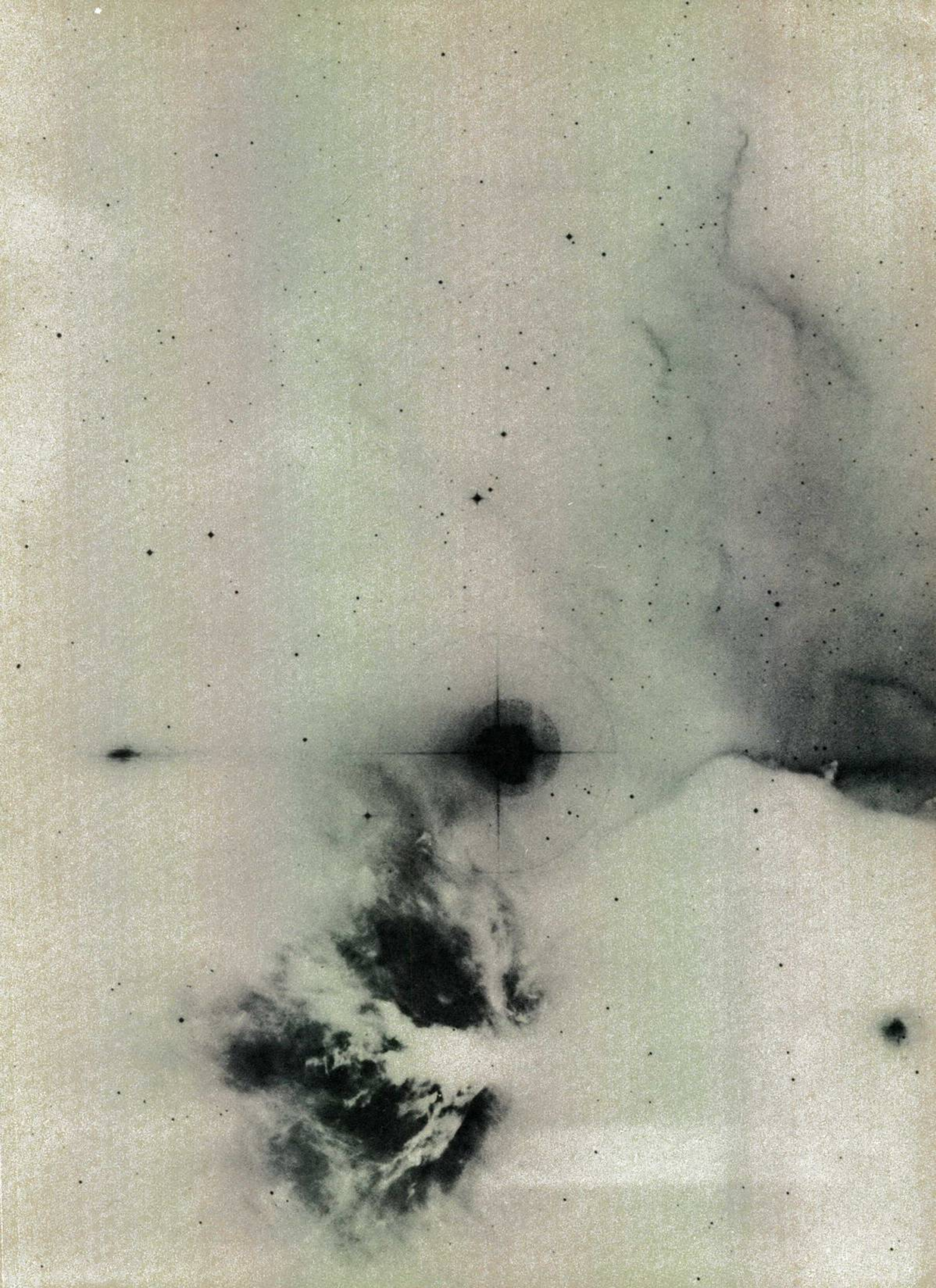
Until recently, this was a difficult question to answer. The only lines produced by the interstellar gas in the visible region of the spectrum arise from elements a billion times less abundant than hydrogen: calcium, sodium, potassium, and titanium. The problem centers on an observational difficulty — spectral lines from the most common atoms in the universe are observed best in the ultraviolet. As it happens, the ozone layer in the Earth's atmosphere throws up an almost opaque barrier for the earthbound astronomers who study these wavelengths. But Copernicus and the International Ultraviolet Explorer (IUE) — two ultraviolet observatory satellites launched in the 1970s — orbited above the ozone layer and found these predicted lines. Their findings also raised new unexpected problems.

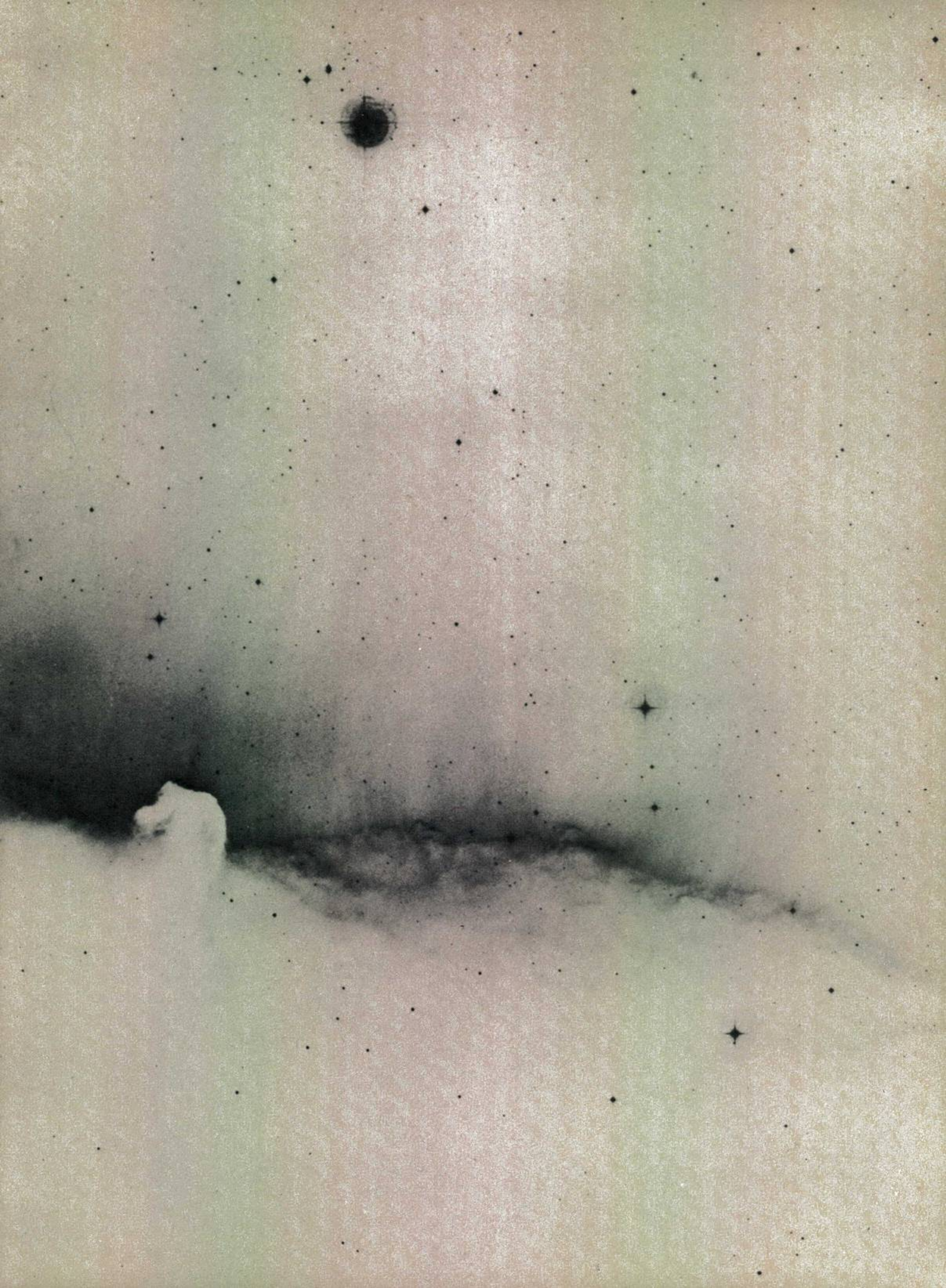


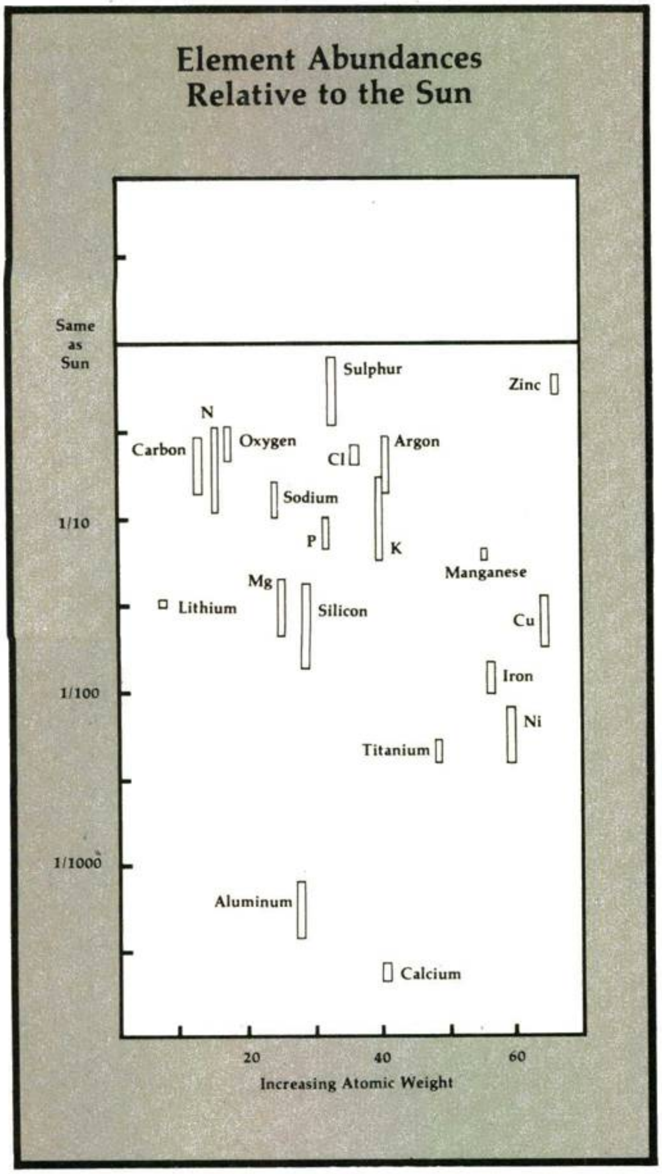
The ultraviolet spectrum of Zeta Ophiuchi taken by the Copernicus satellite shows strong interstellar absorption from carbon, nitrogen, and several other cosmically-abundant elements. From these spectra and from measurements of the strengths of spectral lines in the visible region of the spectrum, the pattern of chemical abundances in the interstellar material can be determined.

The line of sight between us and Zeta Ophiuchi contains only about 10^{20} hydrogen atoms. Although this sounds like a very big number, it really represents only a sparse scattering of matter. If some long-armed astronomer could scoop up all the gas along the 520 light-year line of sight to Zeta Ophiuchi, he wouldn't have enough to fill a child's balloon. On the other hand, remember that our line of sight is just a thin column through a vast expanse; the cloud as a whole contains the mass of several stars.

When astronomers put together all the data on the shapes and intensities of interstellar lines, a picture of a "typical" interstellar cloud emerges. It is







Left: If we use the abundance of elements in the Sun as a standard, many elements in the interstellar medium appear depleted. This diagram shows the abundance of elements that lies between us and Zeta Orionis. Right: The Lagoon Nebula in Sagittarius displays bright hydrogen gas and darker material. Photo by Kitt Peak National Observatory. Overleaf right: The Eagle Nebula in Serpens shows hot young stars, gas, and dark molecular clouds. Photo by Hale Observatories.

about 25 light-years in diameter, has a density of from one to 10 atoms in every cubic centimeter of space, and contains the mass of some 100 Suns. But this standard cloud is about as accurate a picture as the statistician's "average American."

Clouds come in all sizes, from small concentrations only a few times the size of our solar system to vast expanses of gas, hundreds of light-years across. The small clouds, which produce weak absorption lines and have less chance of being seen against a bright star, tend to be overlooked in surveys. Large clouds may not be recognized as being all the same feature if their absorption lines fall in spectra from stars too widely spaced on the sky. But whatever their size, clouds congregate in the spiral arms of the Galaxy, close to the galactic plane, where they rotate about the galactic center with the same motions as nearby stars.

Astronomers think these cool interstellar clouds are the precursors of H II regions, globules, and stars. Triggered perhaps by the advancing shock waves from a supernova explosion, they fragment and collapse into smaller and denser pieces. The highly visible fluorescent gas of the bright H II regions is simply leftover material heated by the newly kindled fires of its stellar offspring. Interstellar clouds are also the temporary resting places for stellar material which, having been processed by nuclear reactions in the cores of stars, is finally returned to the interstellar medium by supernova explosions or the more gentle gusts of stellar winds.

This leads us to the conclusion that the chemical composition of the interstellar gas ought to match the elemental abundances of stars and H II regions — but this is where some unexpected problems confront astronomers. The abundances determined from extensive Copernicus observations do not support such a simple conclusion.

While hydrogen atoms appear to be as common as expected, a large number of atoms seem to be "playing hooky." Calcium, for instance, is almost a thousand times less abundant in the interstellar clouds than in stars. Aluminum, titanium, nickel, copper, and manganese are also severely depleted, and most elements seem at least slightly diminished. If interstellar clouds are the stuff stars are made of, why don't we see absorption from the atoms we know should be there?

Astronomers currently think that the missing atoms are locked up in small solid grains of interstellar dust. The exact composition of the grains is not yet well established, but the abundance pattern of the missing elements favors this conclusion. Moreover, the most depleted elements are those which would condense most easily from the interstellar gas onto a solid surface. They are also those which are most refractory — the most resistant to evaporation by starlight.

But our knowledge of the interstellar medium is far from complete, and new surprises appear every time our surveys expand to include new wavelengths, new sensitivities, and new regions of the sky. Other Copernicus observations revealed features that do not fit into a simple picture of huge clouds of cool gas jostling about in the galactic plane. For example, interstellar lines from very hot gas — temperatures in the hundreds of thousands of degrees — were detected in a great many spectra. Some of these *coronal lines* may arise from a thin intercloud medium which some astronomers have suggested fills the space between the clouds. Some may arise from layers of gas at the edges of clouds that are compressed and heated by the shock waves of supernovae.

Studies of interstellar absorption lines yield a wide range of information on the temperature, composition, and motions of gas, but they are only one of several techniques for discerning the properties of diffuse gas clouds. Neutral hydrogen atoms, for instance, emit radio waves at a wavelength of 21 centimeters which tell us about the distribution and overall motion of the gas. By observing the reddening and polarization of distant starlight, we

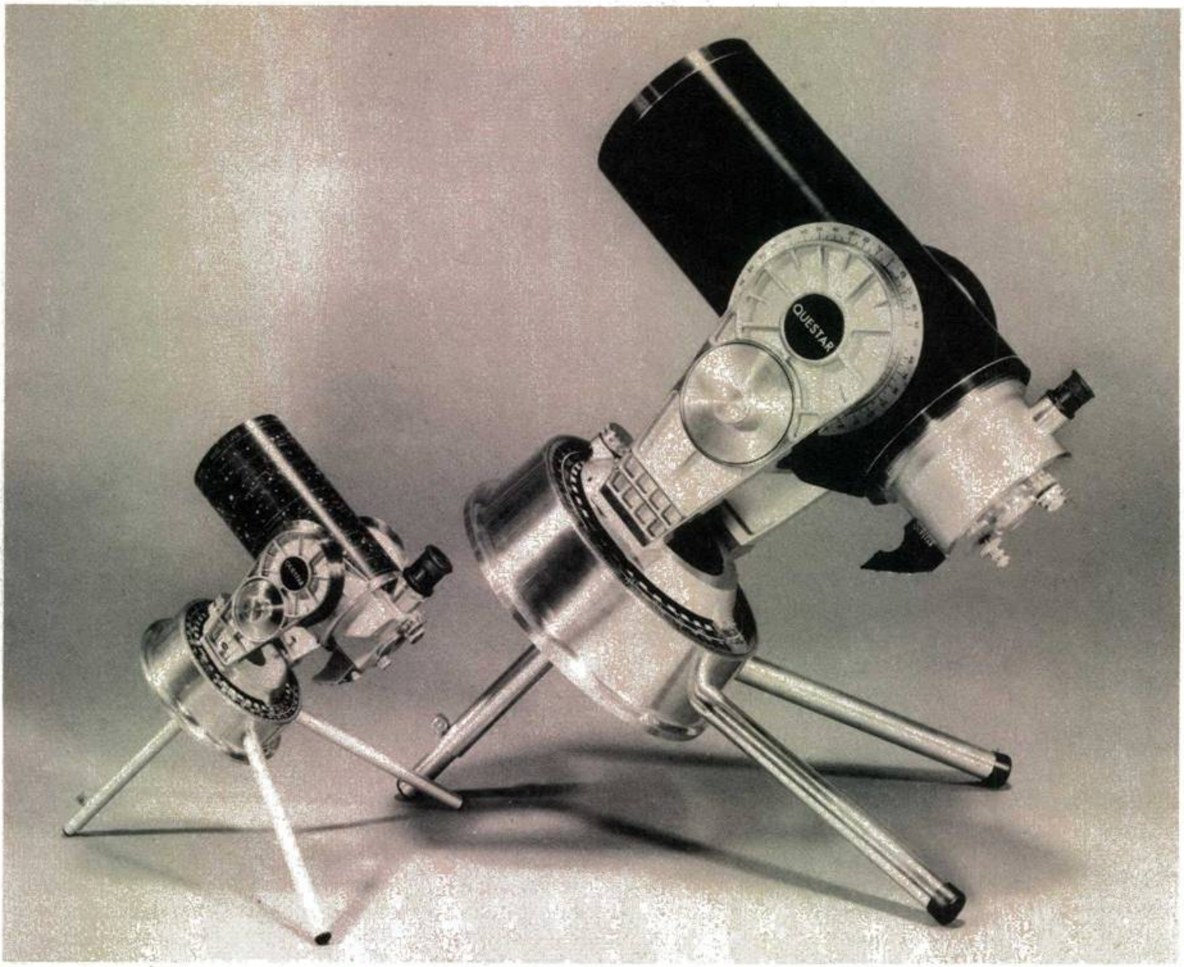
Stars that have more than about 1.4 solar masses will explode in supernovae — as the Crab Nebula in Taurus did in 1054 A.D. These explosions blast elements such as iron and carbon back into space. Eventually these reworked elements will become the raw materials from which a new generation of stars will form. Virtually every element in you, the Earth, and the rest of the solar system, was manufactured in such a way. Photo by Lick Observatory.

learn about size and composition of the grains of dust in the clouds. Depending on their physical conditions, molecules can emit or absorb electromagnetic radiation. And electrons in the gas can alter the arrival times of radio blips from pulsars. Each phenomenon we detect adds a new perspective to our understanding of the makeup of interstellar space.

A new and more complex picture of the interstellar medium is emerging from these studies. Clouds are not so much massive blobs, but rather sheets and tendrils of gas that snake along the spiral arms, confined and compressed by the shocks of supernovae and the gravitational density waves of our Galaxy. They are surrounded by a very thin, hotter gas and are perhaps subject to the effects of the galactic magnetic field.

The apparently empty interstellar spaces are neither dull nor void — and there, almost hidden from view, nature's rich drama is played out as fully as it is in the stars themselves. If we ignore the "space" in our studies and concentrate only on the glowing stars, we miss much of the challenge of astronomy.

Laurence Marschall is associate professor of physics at Gettysburg College and director of its observatory and planetarium. He is working on proper-motion studies of young open clusters. For a hobby, he chases eclipses.



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ASTRONOMY FORUM

An Interview with Robert Burnham, Jr.

Editor's Note: Robert Burnham, Jr. is the author of Burnham's Celestial Handbook, *a 2,000 page tome that lists, constellation by constellation, an incredible amount of information about the sky. He interviewed himself for ASTRONOMY at his home in Flagstaff, Arizona.*

Q: You know, Bob, this is the first time I have ever interviewed the author of a two thousand page book.

RB: Don't be nervous. I'm really quite harmless if taken in moderation.

Q: That's what your friends said. They also warned me not to get you started on Chinese poetry or we'd be here all night.

RB: Ah, I must speak to them. Please continue.

Q: Yes. You are the author of the largest deep-sky guidebook in existence, about one-and-a-half times the size of *War and Peace*. And probably one of the largest projects ever undertaken by a single person. I'm sure that many readers must be curious. . .

RB: Right now you're probably asking yourself: What sort of creature could possibly compile and type a 2,000 page book, and stay stubbornly with such a hopeless project for many years? And remain even partly sane?

Q: Yes, that *was* what I meant.

RB: Obviously such a person must be either a warped genius or a first-rate crank. Right? And wouldn't you like to know?

Q: They say that genius is akin to madness. Do you think that's true?

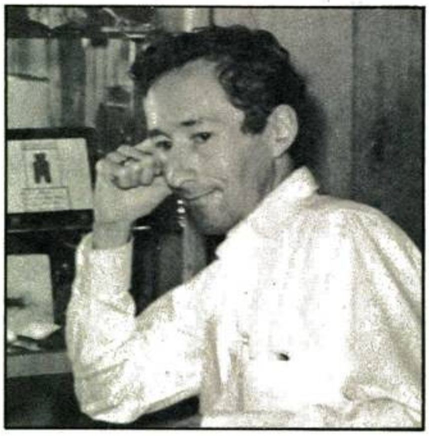
RB: Obviously. But so is normality. We're all a lot crazier than we think. Though we show it in different ways. I'm a virtual hermit, for example, and never attend astronomical meetings.

Q: Why is that?

RB: I can't stand being crushed in the center of a seething mass of astronomers. It's like getting caught in a yak stampede in the New York subway.

Q: Where do you get. . .

RB: Such phrases? Same place Shakespeare got his. The human mind is a bottomless pool of images. You don't know what will come up until you start dredging. That's what poets do. My own brain is like the Smithsonian. Uncle Sam's attic, they call it.



Q: Tell me, did you actually start out with the deliberate intention of producing a 2,000 page book?

RB: Good Lord, No. The whole thing started quite innocently. It's like being born, you know. At the time, you have no idea you're being shoved off a cliff.

Q: But when did you begin the book?

RB: Oh, close to thirty years ago — in the early '50s. I had a small refractor then, and a copy of *Norton's Star Atlas*. After I began to get familiar with the constellation patterns, I started out with a 6-inch mirror, and later on, an 8-inch.

I began to wonder about all those thousands of objects shown on *Norton's* — double stars and clusters and nebulae and galaxies — for which I had no data at all. All these things with Struve numbers and Herschel designations and other esoteric symbols. I wondered where all the information was on these objects — some sort of guidebook that would list them all, with the main facts and data.

Q: There's *Webb's Celestial Objects* . . .

RB: I had a copy of Webb, of course. But by the 50s, it was getting deplorably out of date. And then the Skalnate Pleso *Atlas Coeli* came out with a great catalog. But it was strictly a listing of data. No descriptions or photographs.

Q: So you started your own.

RB: Yes, for some years I kept adding data to the thing. It was a loose-leaf notebook, so that it could expand indefinitely. I kept stuffing facts and pictures into it from any source I could get my hands on.

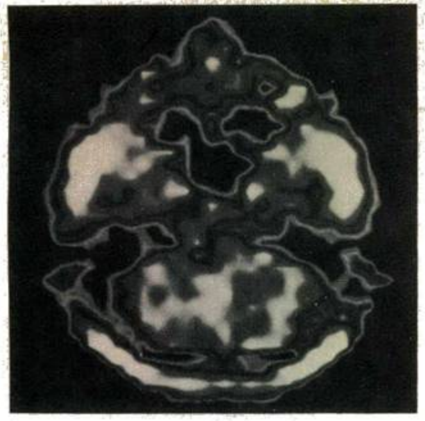
Q: You had no intention of publishing it?

RB: Oh no. It was a compilation for my own use. Plus a record of my own observations. And that was the situation up to one damp night in October 1957, when fate sneaked up behind me with that piece of lead pipe.

Q: I see you read P.G. Wodehouse.

RB: Yes, old thing. I had been using the 6-inch, you see, making some rough measurements on double stars in Cetus for the book. And just before quitting I thought I'd make a quick check on Mira, the classic long-period variable.

Now my 6-inch was *the* basic telescope reduced to the ultimate essentials. No drive. No finder. No setting circles. You point it and sweep. And while doing this I came across the field of 66 Ceti. And



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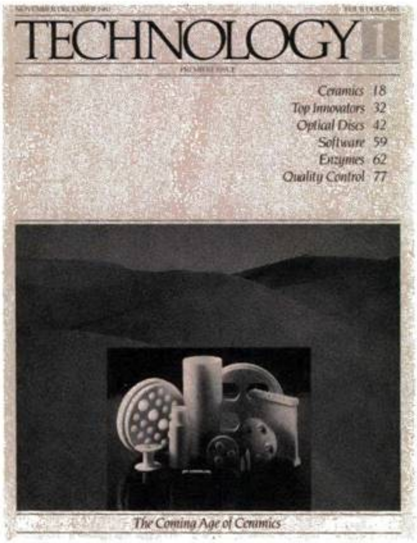

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there, a degree west of the star, was a large fuzzy nebula with a faint star-like center. Now if you check *Norton's*, you'll see that there is no bright nebula a degree west of 66 Ceti.

Q: Had you found a comet?

RB: Yes. A new comet. Seventh magnitude, and going southwest about 13 degrees per day. unusually close to the Earth, obviously.

Q: That must have been your most exciting moment in astronomy.

RB: Up to that time, yes! The discovery was made from my home in Prescott, Arizona, so it was a simple matter to call the Lowell Observatory in Flagstaff. The gentleman who answered the call was Dr. V.M. Slipher, though I didn't know it at the time. The existence of the comet was confirmed rather quickly — you could see it in a pair of binoculars.

Lowell Observatory Photograph

I sent a telegram to Harvard the same night. A few days later the word came that the comet had been picked up independently, about twelve hours earlier, by Paul Wild in Switzerland. Still later we got a third much-delayed announcement from the Russian astronomer Latyshev. Eventually all three of us shared the honors. This was Comet 1957f. It never quite got to naked-eye brightness.

Q: Was it this discovery that led to your position on the staff at Lowell Observatory?

RB: Eventually. A few months later, when the Lowell proper motion sky survey was getting under way, I was offered employment on the project. The Lowell library was an absolute revelation, of course. And the collection of plates made with the 13-inch astrograph. Here was the entire sky down to about 40° south, on huge glass plates measuring 14 x 17 inches — nearly 3,000 of them, going to the seventeenth magnitude.

Q: These were the plates used in the survey you mentioned? You were looking for new stars of large proper motion?

RB: We started out with the intention of doing the entire northern hemisphere at least, down to the plate limit, and recording all stars with motion more than one-third of a second of arc per year. The plates were compared bit by bit in the blink-comparator, with an interval of about thirty years between the two exposures. They had been made chiefly by Clyde Tombaugh and his associates during the search for Pluto.

Q: And you took the new photographs to match?

RB: Yes, we took them region by region as the survey progressed. Three of us worked on the project. The final catalog for the northern hemisphere listed close to 9,000 stars, more than half of which were new discoveries. Along with these, of course, we also re-discovered all the known stars of large motion.

Q: Including Barnard's Star?

RB: Oh yes. We used to keep that set of plates handy to demonstrate the blink technique for visitors. Barnard's Star jumped nearly three-quarters of an inch on the blink screen. Rather hard to miss.

Q: You found no new motions to equal that?

RB: Nowhere near it. The largest new motions were a little under three seconds of arc per year. As a by-product of the survey, we also identified something like 1,700 faint blue stars and white dwarf suspects. Enough to keep the astrophysicists busy for years.

Q: Any comets?

RB: Four during the Lowell survey, plus one discovery with my own 8-inch reflector. A total of six. The real goody of the collection was Comet Burnham 1959k, which showed a periodic swing in the direction of its tail. That got me some humorous newspaper publicity. "Things must be pretty happy in outer space," wrote one columnist, "for, way out there, there's a comet wagging its tail! Maybe it's coquetting with the Dog Star!"

Q: Do you still hunt for new comets? With a few more you could break the record.

RB: I still comet hunt — though I don't think that another new comet would thrill me much any more. Not unless it was one like Ikeya-Seki. As for records — you have to get the Guinness people interested. Then we'll all know.

Q: Do they have an entry for the largest astronomical handbook?

RB: (laughing) Not that I know of. But I don't think there are many people around who have written *any* book of over 2,000 pages.

Q: That deserves to set some sort of record!

RB: For audacity, at least. It takes a certain amount of crust to produce something that is almost certain to get you more criticism than praise.

Q: Criticism?

RB: To be truthful, not nearly as much as I expected. There are certain people, of course, who have been raised on the tradition of the Infallibility of the Written Word. If you publish an error, you're disgraced for life.

Q: But anything so big is bound to contain *some* errors.

RB: Even if I were absolutely infallible, there would still be errors inherited from standard catalogs and reference sources. And I can tell you that those are far from rare.

Not to mention the problem of proofreading 2,000 pages of data. It leaves you goggle-eyed. With symptoms not unlike those of minimal brain dysfunction. The Empire State Building could go by and I wouldn't see it.

If you have a short article, of course, you can take it to an astronomer friend and say: "Check through this, would you, when you have the time?" But try that with a 2,000 page manuscript!

Q: We know the problem. Tell us, has the book won awards of any sort?

RB: Not yet. But it won't, since it doesn't fall into any categories. It isn't a Ph.D. thesis; it isn't research; it isn't even a noble attempt to interpret science for the general public.

Q: That's bound to be a problem with something more or less unique. Someone should start a society in your honor and nominate you for the first award. There is a Webb Society, isn't there?

We are dealing with something that resembles a great symphony or a great poem more than it resembles a huge machine.

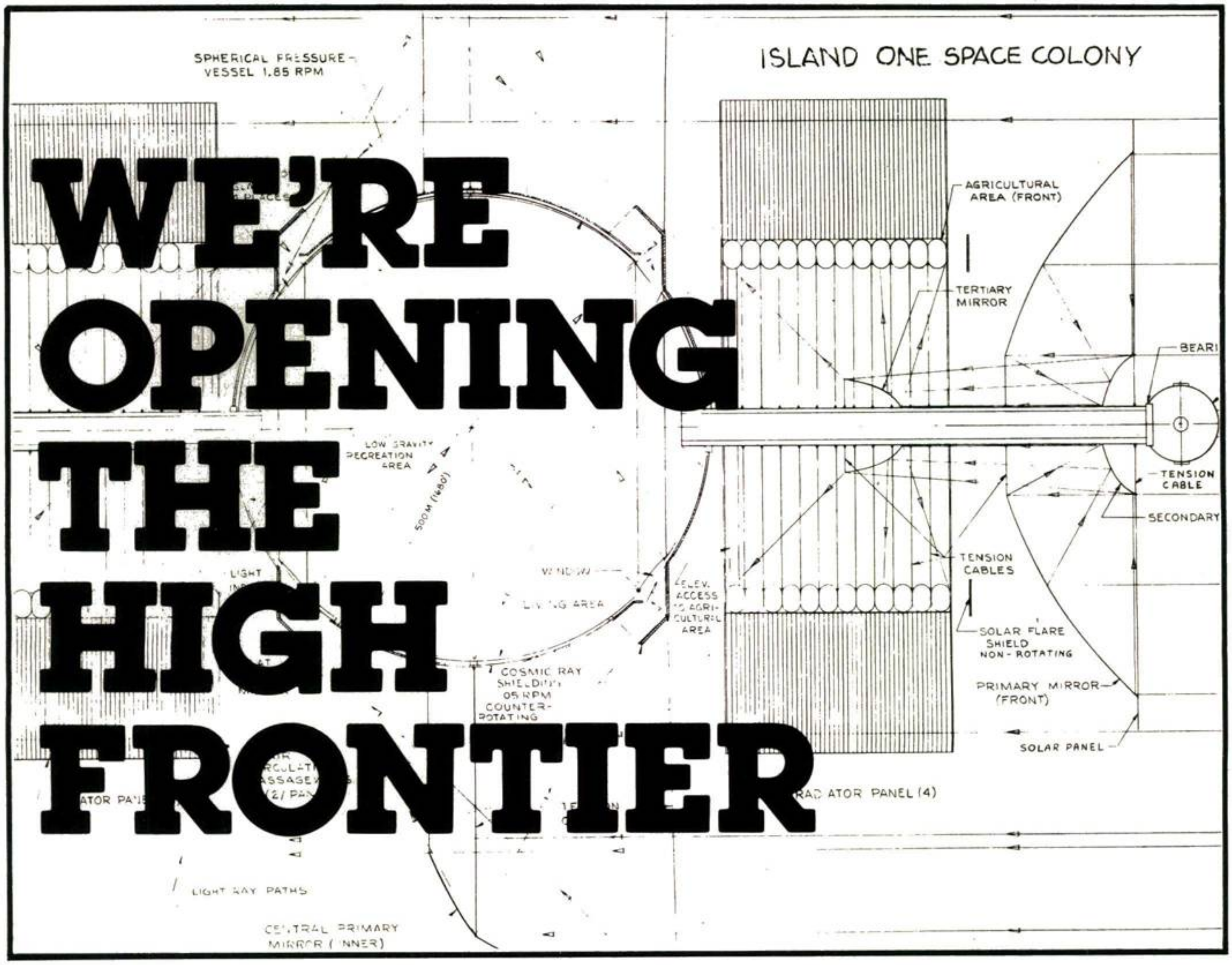
RB: Yes, in England. They've published four fine volumes in a series of observing guides.

Q: But no Burnham Society yet?

RB: I'm afraid not. I think it works something like getting your picture on a U.S. postage stamp: you have to be dead first. I can hardly wait.

Q: When did you first seriously consider publishing the *Handbook*?

RB: It came on gradually, like a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headcold. In 1963 or so, when I was using Webb's quite a bit, I began to think: "This is really absurd. Here's something that was first published in 1859, and over a century later it's still being offered to the modern observer as the most complete deep-sky handbook available." Even though it was revised in 1917, it was still an antique. This must set some sort of record in the annals of long-term lethargy.

Q: But a new edition of Webb did appear about 1963, didn't it?

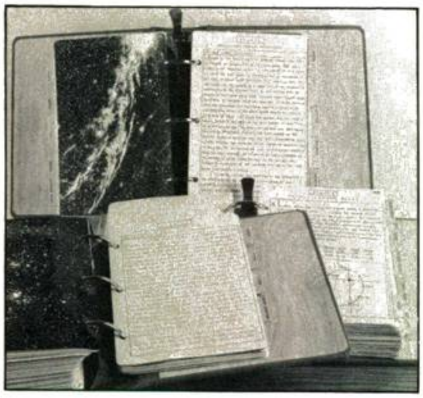
RB: Yes, a reprint was issued, and one reviewer — Leif Robinson, I think — pointed out that no real attempt had been made to update obsolete facts and interpretations, and what we really needed was a new deep-sky guidebook written for the 20th century observer.

Q: So you answered the call.

RB: Well, I tried to. But nobody seemed to be very interested. The size of the thing was usually the chief objection. I estimated then that the total would run to about 1,400 pages.

That was considered completely impossible. I tried the large astronomical publishers. Some thought that there wouldn't be a demand for anything like it. Others said that there was no way to finance such a thing.

One publisher said that they would have to hire someone full time for a couple of years just to check and edit the material. That would be a requirement, they said, if they were to publish. But the cost of doing it that way would make the project impossible, of course.



Q: That must have been very discouraging.

RB: That was the high point of the conversation. After that, things started to go downhill.

Q: You tried being your own publisher, didn't you?

RB: Yes, but don't remind me of it. The memory of those days still causes me to leap from my pillow with a loud cry. I have a recurring nightmare where I'm trying to publish the *Encyclopedia Britannica* from my kitchen table . . . Ouch!

Q: Such guides are available in other languages. Why not in English?

RB: The astronomical world offers virtually nothing in the way of support, incentive, or rewards. It was Don Marquis, I think, who said that publishing a volume of poetry was like dropping a rose-petal down the Grand Canyon and waiting for the echo. He could have been talking about a project like mine.

Q: While you were waiting for that echo, did you consider the academic publishers?

RB: Of course. Academic publishers have a major problem: their books are so immensely overpriced that only a few academic libraries can afford to buy copies. At the typical per-page rate, the *Handbook* would run about $200 a set. That would put it far beyond the reach of the eager amateur for whom it is intended. I couldn't afford to buy a copy myself.

Q: The financial angle was always the reason for the rejection of the book?

RB: Well, let me put it this way. A very large book, directed toward a fairly limited audience, is not the sort of thing that publishers go wild over. It is not "economically feasible." And of course you're told that the times are hard and money is tight. And no one wants to take the risk.

Q: Money is always tight? . . .

RB: I have never known a time when it was loose. It seems that the times are *always* hard. The modern world has become a permanent crisis. But for some odd reason it is always the educational, scientific and cultural activities which are cut back ruthlessly when money is tight.

Museums are in trouble. Schools and colleges are in trouble. The space program is in trouble. Symphony orchestras are in trouble. Basic research is in trouble. Yet there always seems to be plenty of money to build a new shopping center or a new chain of motels, a missile system, or a gambling casino.

I don't see anyone cutting back on the production of junk, schlock, and tripe. The nation's commercial presses grind out incredible trash by the megaton. How much does the American public spend each year on third-rate movies, cheap magazines, fringe-cult pseudo-science, junk food, and astrology? Last year the money spent on tobacco in this country came to ten million dollars a *day*. If we have that much money to burn, I don't think we're exactly short of cash.

Q: The people say it's their money, they earned it, and it's their right to spend it as they choose.

RB: Of course. And manufacturers say that they have to give the public what it wants. And of course the public vastly prefers astrology and pseudo-science over astronomy and general knowledge. We can blame the public, or the educational system, or the commercial racketeers who exploit human ignorance. But in the last analysis, the scientists themselves must shoulder much of the blame. Obviously, they have done an inadequate job of informing the public about science.

Educational, scientific, and cultural activities are cut back ruthlessly when money is tight.

Q: You're asking for something which is not exactly easy.

RB: No, it isn't. Scientists get very bad press. Isaac Asimov, in one of those entertaining "My Turn" editorials in *Newsweek* once said that there is a cult of ignorance in the United States, and always has been. There is a strain of anti-intellectualism winding its way through our political and cultural life, as he put it. And science gets the blame, rather unfairly, for the misuse of technology. So anyone who shows any signs of brains, wit, or talent is denounced as an egghead.

Q: Are you an egghead?

RB: I think of myself as a human being, though the evidence is still not entirely conclusive.

Q: Do you think that scientists could improve their image by taking a different approach?

RB: Let's consider just one current trend: the spectacular revival of belief in astrology. Very few scientists have bothered to do anything much about this at all. In the first place they don't have the funds to combat such a lucrative industry. And in the second place they think the whole thing is beneath their dignity — and really too silly to bother with . . .

Q: You disagree?

RB: Of course it's silly. But the fact that something is silly doesn't mean that it should be ignored. Hitler was silly. The Inquisition was stupid. The great religious wars and persecutions, I would argue, were thoroughly absurd. But they were also very terrible. The beliefs themselves may be silly or harmless, but a resurgence of medieval-style thinking is no laughing matter.

Q: But when actually facing such a phenomenon as widespread public acceptance of astrology, what can a

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scientist actually do?

RB: You know as well as I do — he points out that there is no scientific evidence for such beliefs. Now the astrologer can afford to laugh at such feeble protests from the ivory tower, since the average American doesn't attach any great importance to scientific evidence. There is no scientific evidence for most of the other things that people believe either.

Q: I get the impression that your personal feelings about astronomy don't exactly match the academic outlook.

RB: Well, I recall the time I was asked to write an astronomical article for the hometown newspaper. I used the phrase "the intriguing mysteries of the universe." I was criticized by a respected professional astronomer for *that*. He said it gave the wrong impression of research. There are no mysteries in the universe, he assured me. Only data that hasn't been analyzed yet.

Q: You obviously don't agree with that.

RB: I would argue that we know very little at all so far, and that virtually *everything* is still a mystery. We are just beginning to find out how to *learn*. There are mysteries all around us which are not going to be explained by any amount of analysis of factual data.

Q: You don't mean the so-called paranormal, do you?

RB: No, no, not at all — though some of these things possibly do deserve more serious consideration from scientists. I'm speaking of things that are part of our normal familiar world, right here in plain sight . . .

Q: For example . . .

RB: *Hamlet*. The face of Abraham Lincoln. Bach's *Toccata and Fugue in D Minor*. And I would add the Grand Canyon.

Q: Most scientists would pronounce the Grand Canyon a remarkable geological phenomenon.

RB: Yes, of course it is. In the same way that a human being is 150 pounds of animated protoplasm. The definitions are not wrong — simply incomplete. This explains much of the public apathy toward science.

The strictly scientific approach seems limited to the mechanical aspects of the world — things that can be weighed and measured and reduced to definite principles that can be expressed either verbally or mathematically. Science, many people say, doesn't deal with most of the things that really matter in human life.

Q: Do you think that your somewhat unorthodox viewpoint made it difficult for you to obtain support for the *Handbook*?

RB: Undoubtedly. There are professional astronomers, it pains me to say, who don't recognize the existence of any such animal as the serious amateur. The only real astronomers, they say, are doing serious research. Then there's everybody else — but they don't matter.

When I pointed out that Webb's book was at least half a century out of date, the response was an apathetic shrug. Who cares? — the days of Smyth and Webb are gone. Astronomy is now Big Science. No real astronomer ever looks at a star except to set the automatic guider for the spectrophotometer. A real astronomer can do research for years and scarcely ever see the night sky.

I don't see the universe chiefly as a huge heap of raw data waiting to be fed into a computer.

Q: And your reply . . .

RB: If astronomy has really come to that, I'd suggest that all the great telescopes be locked up for a few decades so that the rest of us might have our stars back again.

Q: You're primarily an observer, aren't you?

RB: Yes. I don't see the universe chiefly as a huge heap of raw data waiting to be fed into a computer. Collecting factual data is fine. I do it too. But the heart and core of astronomy, to me, is the direct experience of the universe. All the factual information in the world is no substitute for that.

Q: Such a statement brands you as an amateur, some would say — a romantic as well.

RB: I wouldn't argue that. By professional standards, I am not much of a scientist. On the other hand, it is a serious error to present astronomy to the public strictly as a Science.

Since the average human is not a scientist, and has only a limited understanding of science, he's turned off by that approach. "Leave all that kind of stuff to the professor," he'll say, "but don't bother me and don't spend my tax money on it."

A century ago, Emerson lamented that the man in the street does not know a star in the sky. He could still be lamenting today. When everything becomes Big Science, what's left for the average man? But how many Americans would bother to visit Yosemite or the Grand Canyon if they were presented to the public strictly as geological phenomena? Astronomy should be presented primarily as exploration, adventure, and discovery The scientific aspects can come later.

Q: You're what used to be called a naturalist — a species nearly extinct.

RB: Thoreau and John Muir are among my heroes. It was Thoreau who said that it enraged him to buy a book on frogs and find nothing in it except an analysis of bone and muscle structure. Well, I would say that it enrages me to find a book on astronomy which confines itself to strictly physical and numerical data. That's like trying to describe a great work of art and limiting the description to a chemical analysis of the pigment.

The universe cannot be comprehended through strictly scientific techniques. We are dealing with something that resembles a great symphony or a great poem vastly more than it resembles a huge machine.

Q: That's almost a religious statement.

RB: Yes, it is.

Q: But most of your friends describe you as strictly agnostic.

RB: By formal standards I am agnostic. I don't subscribe to any organized creed; I have never felt the slightest need to adopt any sort of definite theology or set system of beliefs. Alan Watts has said it for me: "That would be like trying to wrap up and label the sky."

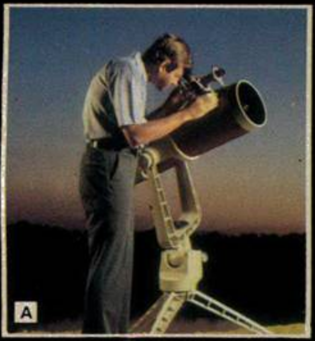
We are all children. If we cannot be wise, we can at least be honest. I accept the existence of what I call the all-pervading intelligence of the universe. The orientals call it the Tao. To me, that is too obvious to need scientific proof. That's my religion — that and the Grand Canyon. And Yosemite. And the surf coming in with the tide. And NGC-6611.

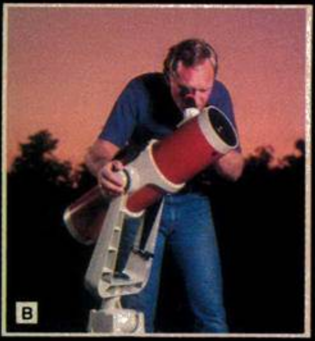
Q: And if you had to put it into words . . .

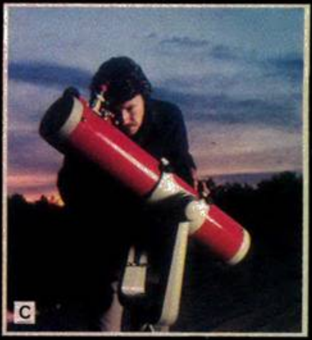
RB: I would say this: There is no ultimate truth about life or the universe which can be expressed in words. Whatever it is, it has to be experienced directly. Words are symbols, never to be confused with the thing itself. The most that symbols can do is to point the way. Your task is to walk down the road, not to worship the signpost.

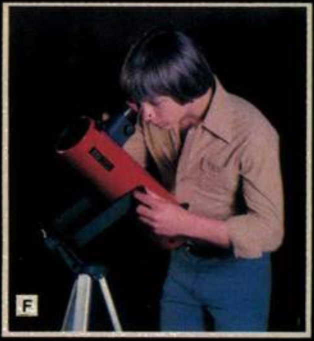
Q: Our readers have noticed you devote space in the *Handbook* to ancient mythology, Chinese poetry, oriental folklore, Roman coins — things like that. If you had omitted all this, do you think you might have reduced the book to a more practical size?

RB: No. It doesn't add much to the page count. And I think it gives









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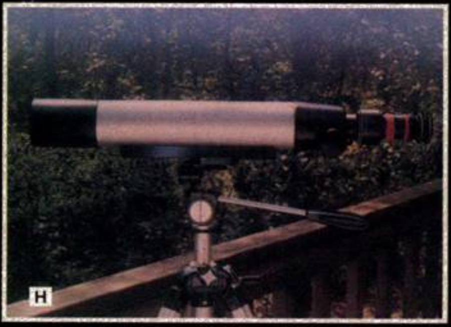

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the work a personality.

Q: Do you think the book will remain unique?

RB: I hope not. There are a fair number of people capable of producing such a thing. A few of them have actually tried. Unfortunately, the majority of these good folk succumbed to concussions after decades spent beating their heads against a solid wall of apathy.

Are we really better off with neon signs, smog, traffic jams, nuclear bombs, and TV commercials?

Q: You were all ready for that question, weren't you?

RB: (laughing) Yes, I'm afraid so. You know, after hearing the same questions so many times you begin to have answers prepared. In the last couple of decades I've been interrogated and catechized by everyone from kindergarten school groups to U.S. presidential candidate Barry Goldwater.

Q: Was that after your first comet discovery?

RB: Yes. The Senator was quite intrigued to learn that someone with a home-built telescope had beaten the professionals to a "major astronomical discovery," as he put it.

Q: And what sort of questions do you get from school groups?

RB: There are two I get repeatedly. First: Would you like to go to the Moon? Yes, if I was sure I could come back. Second: Have you ever seen a flying saucer?

Q: Have you?

RB: I think I have spent about as many hours under the stars as any observer living today. I have never seen anything remotely resembling the photographs in the UFO books and saucer magazines. Orbiting satellites — yes. Rocket launchings from Vandenberg — yes. Skyhook balloons, meteors, refueling tankers, high-flying flocks of birds — yes. But nothing that couldn't be rather easily identified as a known object.

I am especially skeptical of persons who repeatedly claim to have UFO experiences. And virtually all the contactee stories are quite literally unbelievable — aside from the fact that there is never the slightest bit of physical evidence to study afterward. Of course, it's unwise to be too dogmatic; there is nothing inherently impossible in the central idea . . .

Q: . . . that space travelers may occasionally visit the Earth?

RB: We really don't know how many inhabited worlds there may be. We don't even have the data to make an intelligent guess. So we must keep our minds open to the possibility.

But I don't think this possibility has much to do with the present UFO enigma. I can't believe that space travelers are coming here constantly, by the thousands if you believe all the reports, and still managing to avoid all the radar defense networks, the satellite tracking stations, and the telescopes of professional astronomers.

Q: Most of the sightings must be known objects.

RB: Right — misinterpreted. Honest errors. Still, there is a strong incentive for deliberate hoaxers, since the UFO business is a booming and profitable industry.

Q: I gather you don't appreciate the commercialism of the modern world.

RB: Well, a lot of Americans would staunchly defend something they call the American Way of Life, on the grounds that it has given them the highest standard of living in the world. But this life has been achieved by looting the planet, by using vastly more than our fair share of everything. And you simply can't maintain a system by constantly increasing the exploitation of everything. Such a set-up is doomed.

Q: Most Americans would say it's done pretty well — at least up to now.

RB: That's like claiming you're immortal because you're alive now.

Q: Would you call yourself an environmentalist?

RB: Since I live on this planet, yes. Any human being who expects to survive here must be seriously concerned about a world which grows steadily more poisonous.

Q: Well, technology is certainly not magic.

RB: Exactly. There are limitations dictated by the very nature of space and time. Colonization of other star systems, or even other galaxies, for example, seems wildly unrealistic.

Q: Why?

RB: Because of the distances involved.

Q: Technologists may find ways to transcend these limitations.

RB: You mean space warps, maybe, or an extended human life span. Or quick freezing or suspended animation for long journeys. No one has shown that these things are even possible.

Science fiction writers often see their dreams turn into facts, but this doesn't mean that every dream is going to become a fact. Some of my skepticism could look very silly in a few years. But I seriously doubt that most of these things will be achieved in time to solve our present problems. Technological solutions frequently work in reverse — each new solution creates six more problems. You have to run faster and faster just to stay in the same place.

Q: You're saying that the present crisis exists here on Earth and it's going to be faced here on Earth.

RB: Yes. Ask me again in a thousand years.

Q: What about a simpler concept — space colonies in the solar system?

RB: But what do they solve? Not overpopulation. Humanity is growing at close to 200,000 people a day — a new city the size of Baltimore or Pittsburgh every eleven or twelve days. You would have to move people into space at that rate just to keep the population at its present level. Several thousand rocket launchings today, and again tomorrow, and the next day, and the day after that — forever. It becomes completely absurd.

There is no foreseeable type of technology which will ever make such a thing possible. Not to mention the logistics — the organization and red tape involved. And space colonies themselves would have to expand their facilities at the same rate as well — forever.

Q: You don't agree with the enthusiasts who say that humanity's destiny lies in space?

RB: It seems to me that mankind will stagnate and degenerate more rapidly in a space colony than it will here on Earth.

Q: They look okay on paper . . .

RB: . . .but such a thing is only a feeble imitation of a real world. It's a sophisticated hamster-cage. Here's "manufacturing and storage," and here's "living and working" and another area called "recreation." I get a case of the cold mulligrubs when I see one of these things, especially when it comes with the claim that mankind can now abandon the Earth.

Q: You're speaking again as a naturalist.

RB: I'm speaking as a human being. I feel that the whole concept constitutes a giant step backward. Rather than expand human possibility, it would stultify it. Technologists limit much of their thinking to the hardware and the mechanics involved — no one has devoted enough time to the most important consideration: what would it be like to live in one of these imitation worlds?

Q: No real mountains or forests?

RB: Right. No real rivers or oceans. No real seasons, clouds, sunsets, spring rains or winter snows. No Yosemite, no Grand Canyon, no Iguazu Falls. No surf rolling in on the coast, no moonrise over the sea. No peaks to climb or caves to explore or wilderness to experience. a totally man-managed ecology.

Q: You can't even look for arrowheads or fossils or ancient ruins. . .

RB: Right. I don't see much scope in any of this for individual initiative and adventure, and what we call free enterprise. Free enterprise for who? National governments? Gigabuck corporations? No one else can afford to make the staggering investments involved.

The most that the space industry can offer to me is the claim that eventually some of the spin-off benefits will trickle down to the average citizen — for 10% down, and easy monthly payments. Am I going to seek my fortune among the stars, some bold pioneer riding off into the sunset? Right now I can't even afford to fly to New York.

Q: That's your fault — you wanted to be an astronomer. But maybe you'll make a million dollars on your next book.

RB: I'm working on one — *The Chronicles of Deriyabar* — a tale of magic and suspense and high adventure with four young and thoroughly human heroes who learn bit by bit that they have been chosen for a great and splendid destiny. It's got unicorns and dragons and enchanted swords, of course. Lots of joy and humor.

Q: 2,000 pages?

RB: No. Well, not unless I have another spell of insanity.

Q: One last question — how did you get into astronomy, anyway?

RB: When I was nine or so I came across a little book called *Seeing Stars* at the local five-and-ten. It had simple sky maps and some notes on the interesting objects in each area. It cost all of fifteen cents.

Q: Thank you, Bob. We'll all look forward to seeing the *Chronicles of Deriyabar*.

— *Robert Burnham, Jr.*
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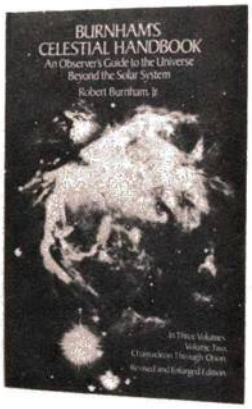

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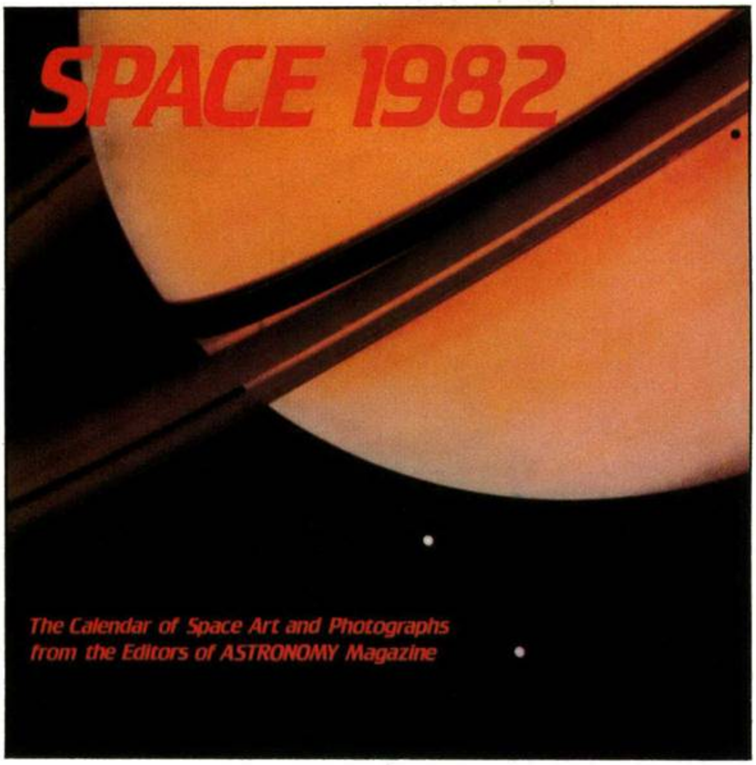
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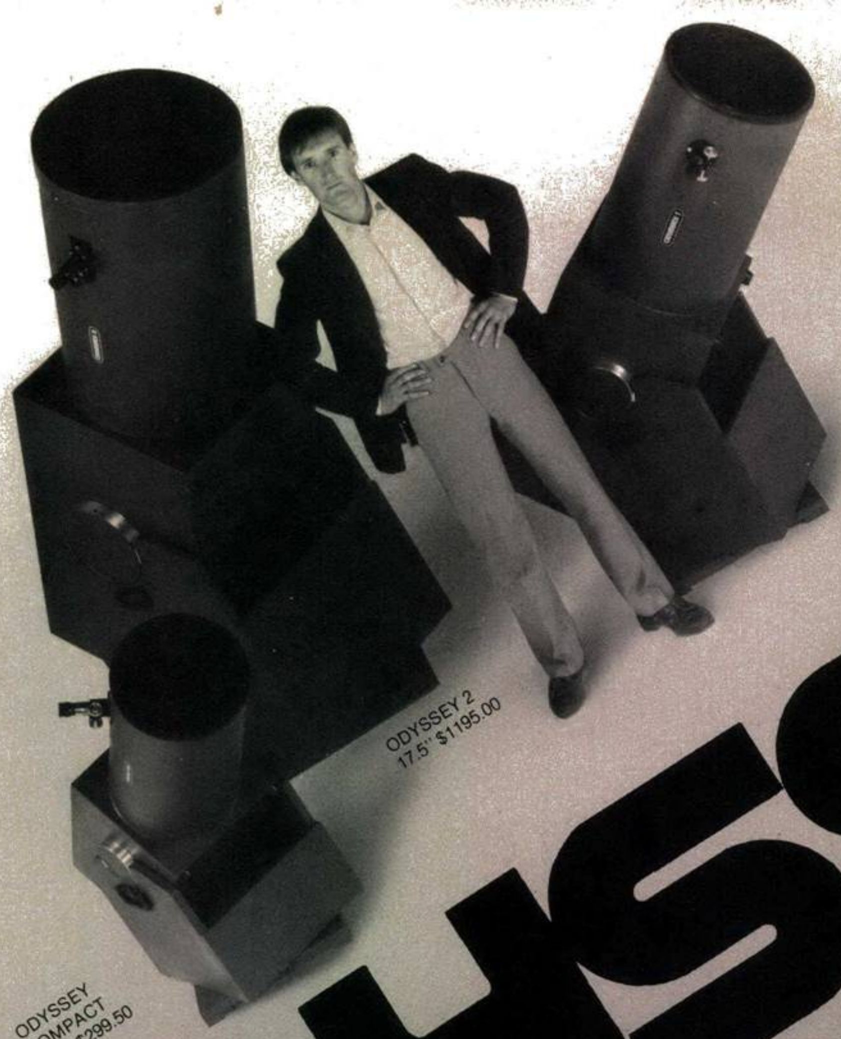

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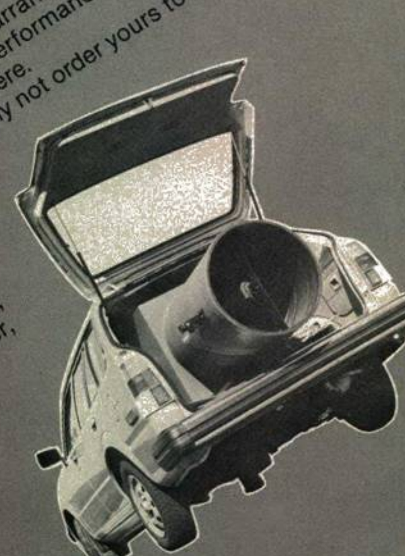

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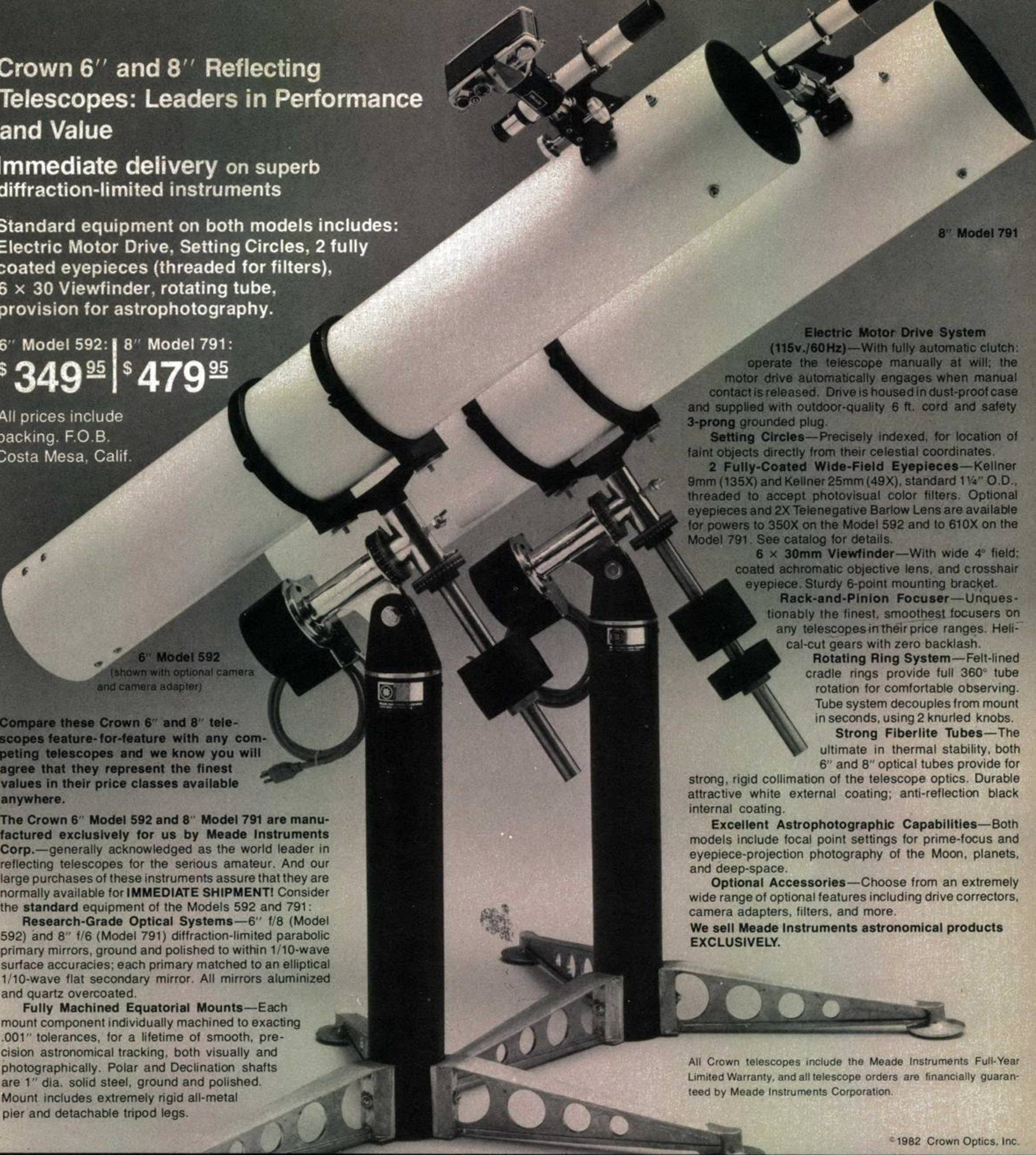

8″ Model 791

6″ Model 592 (shown with optional camera and camera adapter)

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eye on the sky

mars glows red at opposition

by Fred Schaaf

the wanderers

In the past century, no planet has stirred as much scientific controversy and public fascination as **Mars**. Thanks to the Viking landers and orbiters, we now know that Mars is a more inspiring and admirable wilderness of harsh beauties than we had imagined. It is a world of ancient riverbeds, vast volcanos, and ice-caps; of painted or rusted deserts; of pink skies and blue sunsets. However, it is not every year that we get a good look at our impressive neighbor planet from our earthbound telescopes. But this month, when Mars shines like a brilliant and colorful light in our skies, we have a fine chance to observe it.

Mars reaches opposition to the Sun every 780 days, and will reach it this year on March 31. Mars will be at its brightest on that evening — a predicted magnitude of -1.2. Sometimes dust storms on the planet change its brightness enough that the fluctuation is even noticeable to naked-eye observers on Earth!

The brilliance of Mars this month is pale in comparison to what it can attain at its great perihelic oppositions. Its last opposition — beside Jupiter in 1980 — occurred just a few hours from aphelion, and it will be four years before Mars nears a perihelic opposition again. However, Mars will still be an impressive naked-eye object during March — especially with its striking orangey-red color.

All month long Mars moves steadily westward, heading toward a close encounter with Gamma Virginis (Porrima). There will be no occultation, but by month's end Mars will be very close to the star, and on April 1 the planet will pass less than 11′ north of the 2.9 magnitude star. The Red Planet will be closest to Earth on April 5/6 — almost a week after opposition.

Two other bright planets pursue Mars across the sky each night. The first is **Saturn**, closely followed by the first magnitude star Spica. Saturn has no conjunctions in March, except for its reasonable proximity to Spica and Mars, but the ringed giant will brighten to 0.5 magnitude by month's end, when it will be very close to opposition. The second planet in pursuit of Mars is **Jupiter**, approaching an April opposition. This giant easily outshines Mars.

Both inner planets are in the morning sky. Little **Mercury** was at greatest elongation late in February, and is still slightly visible low in twilight for the first half of March. On the morning of March 14, Pacific Coast viewers with telescopes may wish to look for 5.5 magnitude 42 Aquarii just 42" north of Mercury. Mercury will shine at magnitude 0.0, and its elongation from the Sun will be 23°.

Venus shines high above Mercury in the morning sky and begins the month shining close to its greatest brilliancy. Venus is very near 3.2 magnitude Beta (β) Capricorni on the morning of March 8, and by the end of the month is just hours away from greatest elongation. This is a superb month for Venus observers who rise early. Try to see how long after sunrise you can still see the Morning Star with your naked eye.

A less famous solar system body is unusually bright this month. The asteroid **Pallas** will be roughly equal in brightness to the usually far brighter Vesta and Ceres. Pallas shines at magnitude 7.3 on the evening of the 17th — about five days before it is closest to Earth, and about 13 days before it reaches opposition. Only once in the 1980s — in 1986 — will Pallas be anywhere near as bright, and the asteroid will be even closer to Earth this time than it will be at that future close approach. These close oppositions occur very rarely, because Pallas has an unusual, highly-inclined orbit.

One more celestial event happens this month — the beginning of **Spring** for North America — the afternoon of March 20.

the starry sky

As spring arrives this year, you'll see two bright collections of celestial lights opposite each other in the midst of evening. The eastern gathering is composed of several brightening planets and a few first magnitude stars; the western is the gathering of eight traditional first magnitude stars of winter.

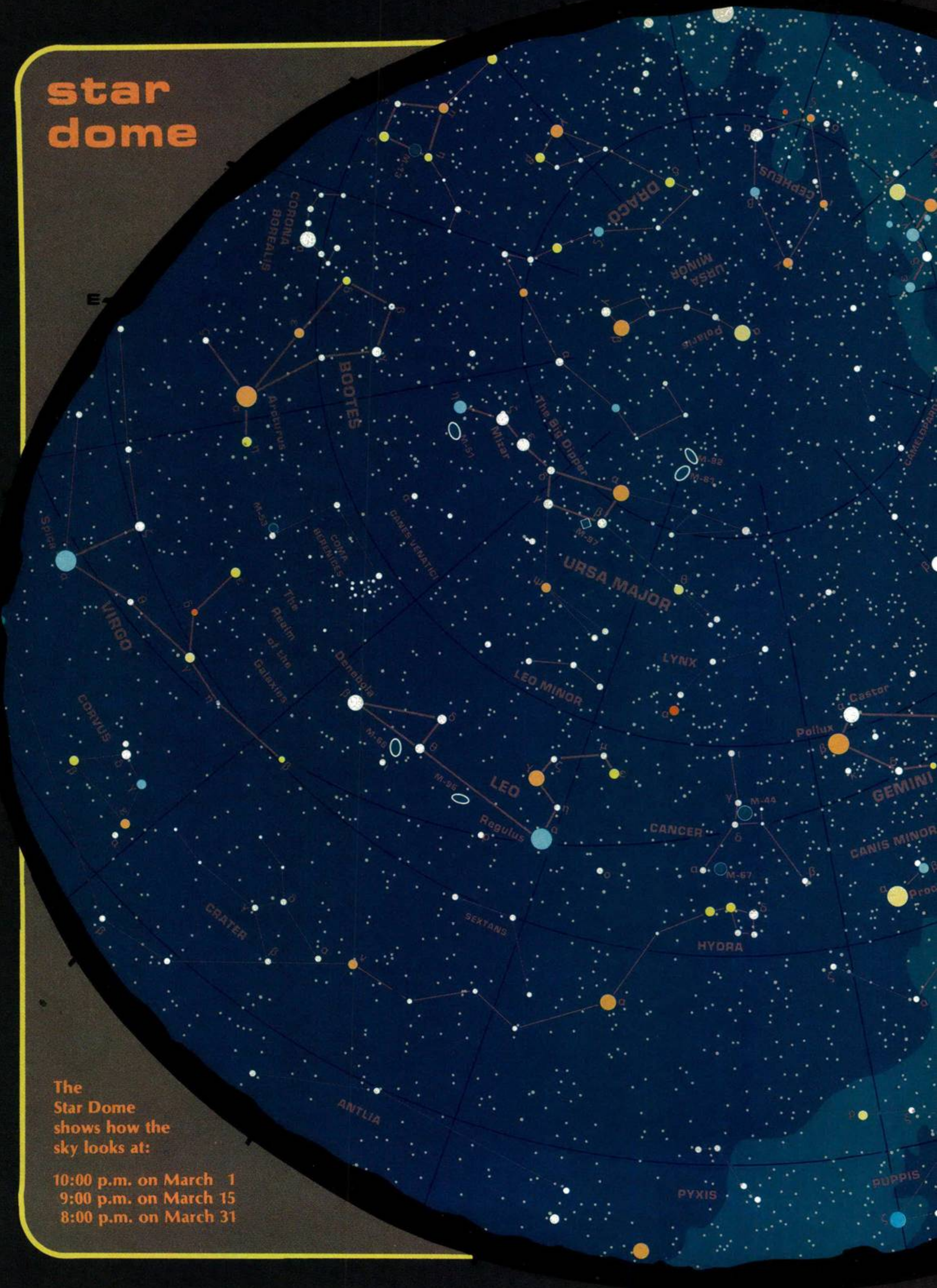
This is the last month for really good views of **Taurus** the bull and **Canis Major** the great dog. The prime stars of Taurus and Canis Major are orange Aldebaran and blue-white Sirius. The latter outshines all other points of light in the sky athough Mars becomes a good rival until it sets and Jupiter rises.

Between Aldebaran and Sirius is the famous Belt of **Orion**, flanked diagonally by Rigel and Betelgeuse. Two bull-horns north of Orion's head is **Auriga** the charioteer, driving his dray, with the brilliant "she-goat" Capella in his hold.

Last month we looked at the fascinating crossroads located at one of the meeting points of the ecliptic and the *solstitial colure* — the 6h line of right ascension — and the galactic anticenter. This spot centers around Auriga, Taurus, Orion and a constellation that is especially well-placed in March — **Gemini** the twins. The foot of the northern twin extends to the "crossroads," and near there, you can find the 5th magnitude open cluster **M-35**. In our tour of luminous

Venus, Jupiter, Saturn and the Moon descended together in front of a star-filled background on the night of August 31. Ronald E. Royer used a 4x5 Speed Graphic with a 135mm lens at f/5.6 to obtain this view. He exposed Ektachrome 64 sheet film for about two minutes while guiding the stars.

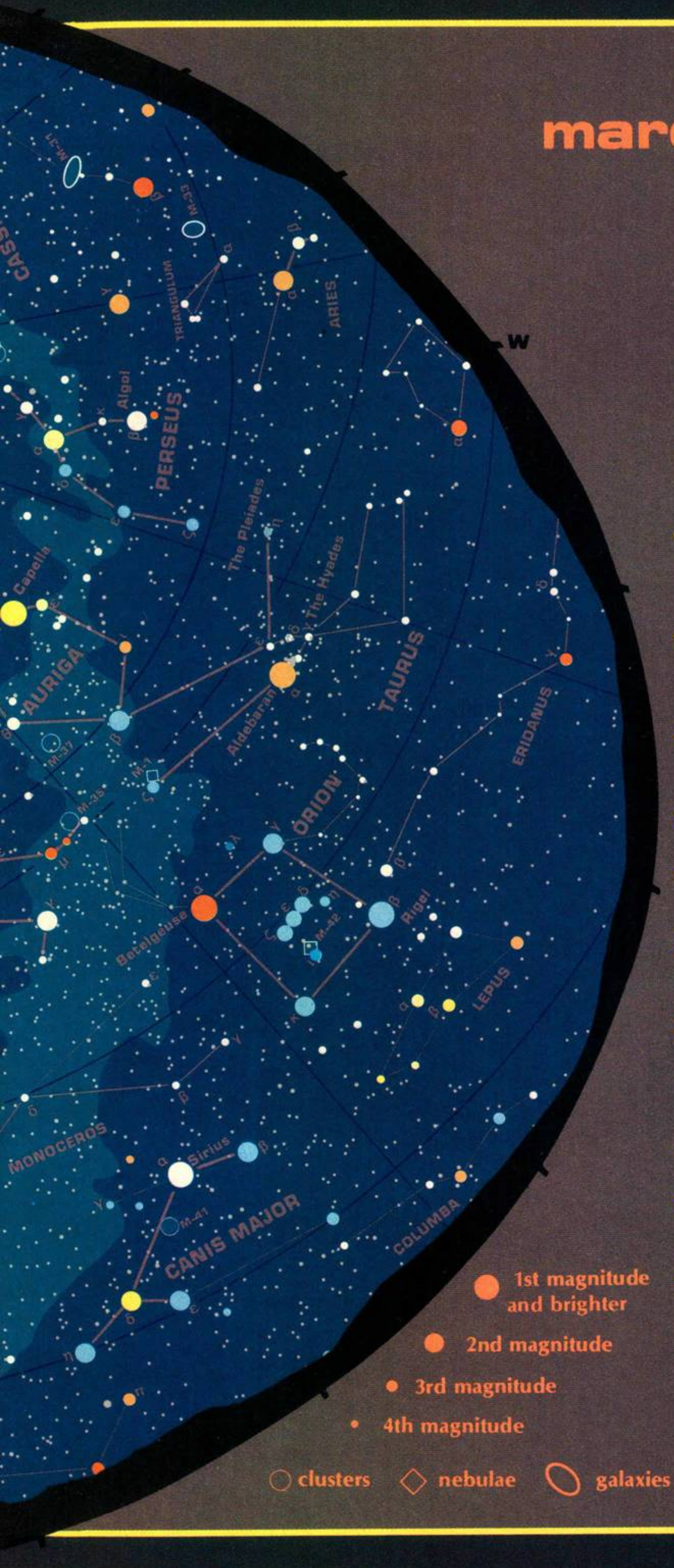
star dome



DRACO
CEPHEUS
URSA MINOR
Polaris
CORONA BOREALIS
BOOTES
Arcturus
The Big Dipper
Mizar
M-13
M-51
M-82
M-81
M-97
M-53
COMA BERENICES
CANES VENATICI
URSA MAJOR
Spica
VIRGO
The Realm of the Galaxies
Denebola
LYNX
LEO MINOR
Castor
Pollux
GEMINI
CORVUS
M-66
M-65
M-95
LEO
Regulus
CANCER
M-44
CANIS MINOR
M-67
CRATER
SEXTANS
HYDRA
ANTLIA
PYXIS
PUPPIS
E

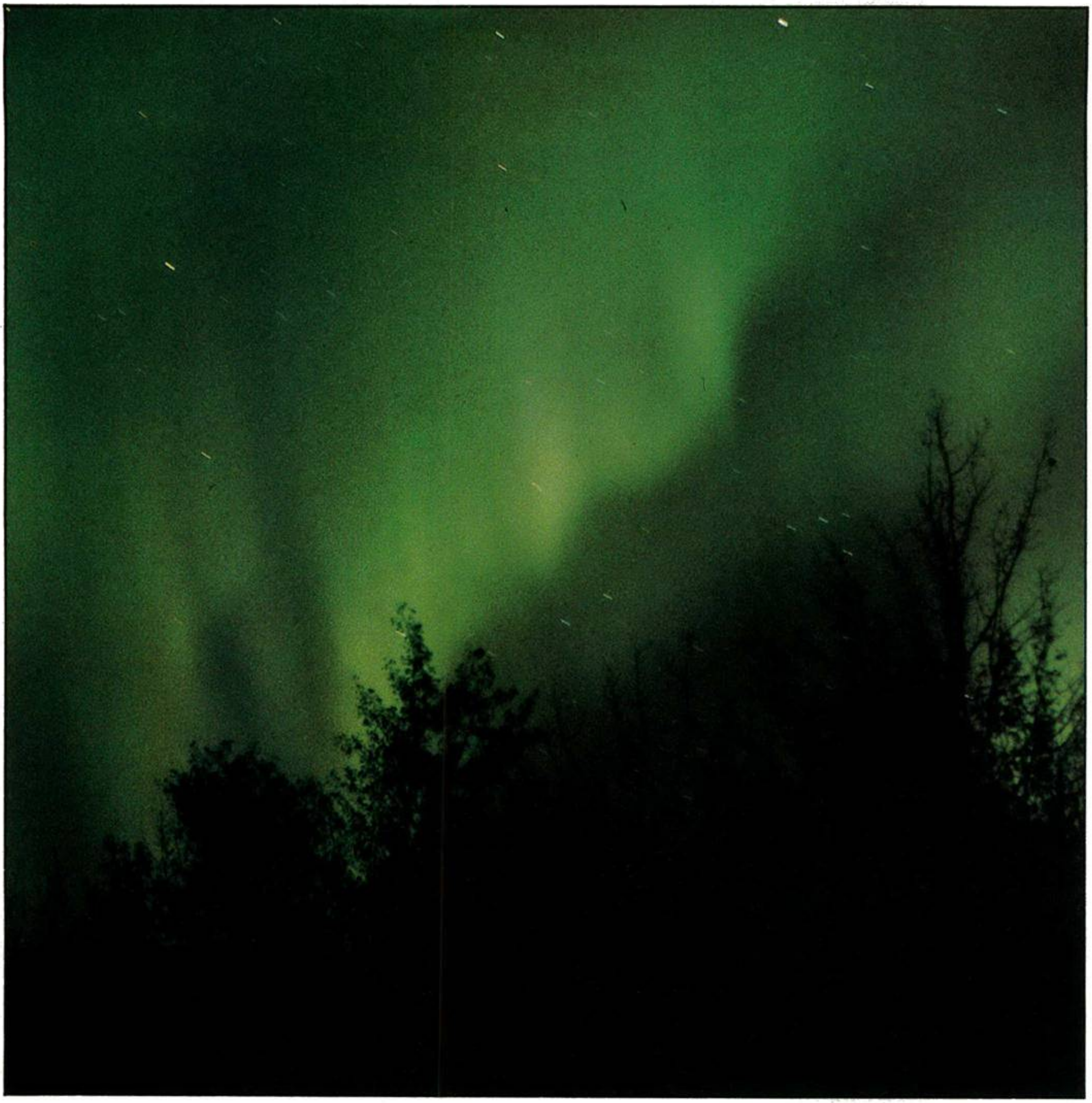
The Star Dome shows how the sky looks at:

10:00 p.m. on March 1
9:00 p.m. on March 15
8:00 p.m. on March 31


W
CASS
TRIANGULUM
M-33
M-31
ARIES
Algol
PERSEUS
The Pleiades
The Hyades
Capella
AURIGA
TAURUS
Aldebaran
M-37
M-1
M-36
M-35
ERIDANUS
ORION
Betelgeuse
Rigel
M-42
LEPUS
MONOCEROS
Sirius
M-41
CANIS MAJOR
COLUMBA
1st magnitude and brighter
2nd magnitude
3rd magnitude
4th magnitude
clusters
nebulae
galaxies

march sky almanac

2nd	First Quarter Moon is at 5:15 p.m. EST.
4th	The Moon is at perigee (closest to Earth) early this morning: 229,845 miles.
8th	Mercury is at aphelion (farthest from the Sun).
9th	The Moon is Full at 3:45 p.m. EST.
11th	The Moon passes 2° north of Mars around 5 p.m. EST; later tonight (around midnight), it passes 3° north of Saturn.
13th	The Moon overtakes Jupiter during the afternoon and the two appear together in the southeast after sunset.
16th	The Moon is at apogee (farthest from Earth) around midnight tonight: 251,220 miles.
17th	The Moon will reach Last Quarter at 12:15 p.m. EST.
20th	Spring begins astronomically for Earth's northern hemisphere at 5:56 p.m. EST.
21st	The Moon, in a slender crescent phase, will lie near Venus in the predawn hours.
24th	About 33 hours before New, the Moon will pass 2° south of Mercury, but both will lie so close to the Sun they will be nearly impossible to see.
25th	New Moon comes at 5:17 a.m. EST.
29th	The Moon is closest to Earth (perigee) early this morning: 228,478 miles.
31st	Mars is in opposition to the Sun at 5 a.m. EST today.



Unfamiliar to many southern observers, the Aurora Borealis is a common sight from Edmonton, Alberta. For this photo, Brian Tkachyk used a 50mm f/1.8 lens wide open with a one-minute exposure on Ektachrome 400 push-processed to ASA 800. Ionized oxygen in the Earth's atmosphere produced the green color.

and distant giants and supergiants, we have missed one such star, located not far from M-35.

The star is a mere magnitude 4.6, **Chi²** (χ^2) Orionis, which with **Chi¹** (χ^1) forms the head of Orion's club. As Guy Ottewell notes in the *Astronomical Companion*, this star is particularly interesting because it is the most distant among the 1,000 brightest in the heavens — those stars with apparent magnitude greater than 4.75. Since most observers in these light-polluted times don't often get to see stars much fainter with the naked eye, Chi² may well be the farthest star you will ever observe without optical aid. This sun, which is 4,000 light-years from us, is next to a star of similar apparent brightness (Chi¹) which is more than 100 times closer.

Back in Gemini we meet two famous stars of similar apparent brightness — **Castor** and **Pollux**. The brighter, Pollux, is 6.7° north of the ecliptic and just barely outside the occulting range of the Moon or any planet. Not so the star Epsilon (ϵ) Geminorum (Mebsuta), that Mars occulted in 1976; or the star Kappa (κ) Geminorum that the tiny asteroid Eros occulted. That was the first of the now famous asteroidal occultations ever observed, and it was spectacular because Eros is an irregularly shaped body which then passed extremely close to Earth. Kappa is not far from Pollux, and Eros actually headed due south for quite a while, passing very close to Pollux and Procyon.

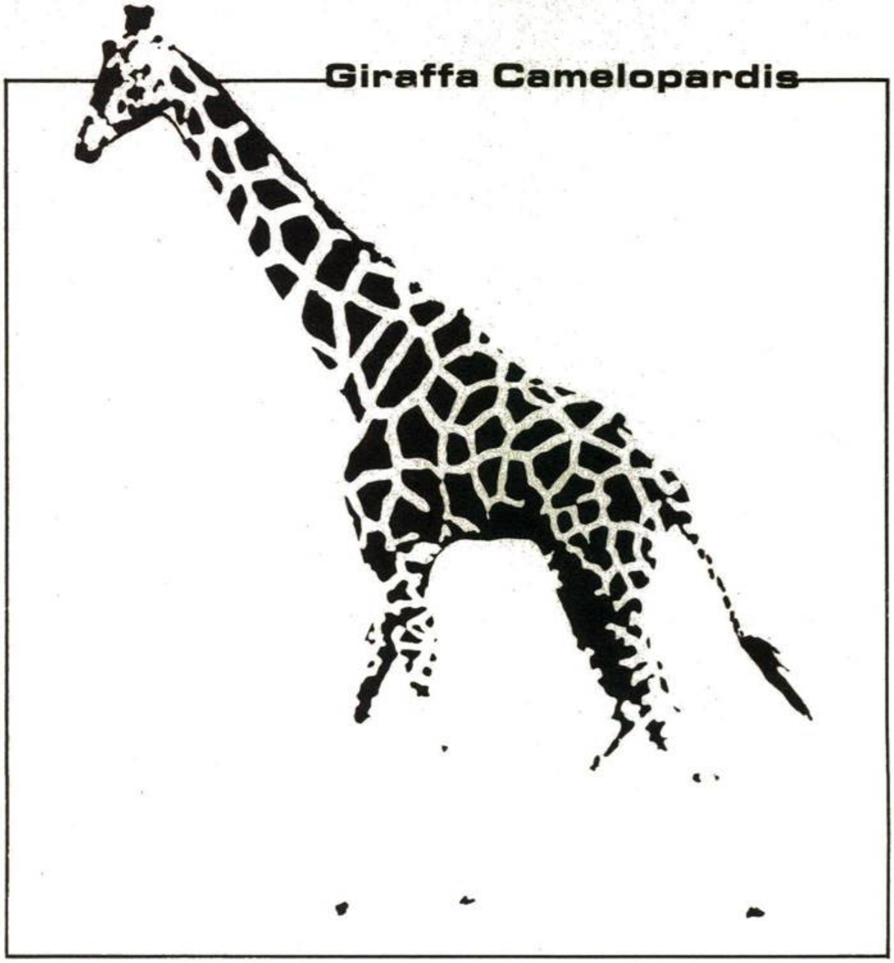
We now come to a dark arch of sky that spans the heavens north to south on March evenings. Besides **Polaris**, the only other conspicuous star pattern here is the head of **Hydra** — the sea-serpent. Hydra is so long that its tail is still below the horizon at this hour. Right above the serpent's head is an inconspicuous yet very interesting constellation, **Cancer** the crab.

Cancer's most fascinating object is

M-44, the **Praesepe**, or **Beehive Cluster**. The Beehive appears to the naked-eye as a large patch of unevenly spread radiance. Binoculars reveal many stars of similar brightness which swarm together and give the cluster its nickname. M-44 is pretty far from the galactic equator, but it is rather near to us as clusters go, so it is not actually too far above the equatorial plane of the galaxy.

Another cluster in Cancer is far from us, and unusually far above the plane. This is **M-67**, which you can glimpse with the naked eye in very dark skies. Because it is so far from the disruptive gravitational influences of other stars, M-67 has remained intact for a long time. It is the second oldest open cluster on record — perhaps 10 billion years old.

In the northeast, the **Big Dipper** swings up with the nose of Ursa Major already nudging the meridian (the line from north to south through the zenith). High in the southeast is noble **Leo** the lion, featuring the big hook of stars called **The Sickle**. The heart of Leo and handle-end of the Sickle is first magnitude **Regulus**. Orion soon descends into twilight, but the rising of Leo and Ursa Major help make up for his departure.



Giraffa Camelopardis

skylore

In the past few months we have looked at a very bright constellation, the brightest planet, and the brightest star. For a change let's consider the dimmest and least conspicuous constellations of all — **Camelopardalis** the giraffe, and **Lynx**.

Both constellations are well placed during March — at least for observers at northerly latitudes. Lynx and Camelopardalis are best known for being among the small class of circumpolar constellations. Actually, Lynx is no more circumpolar at 40° N. latitude than Perseus is. Like Perseus, it extends roughly from +30° to +60° declination.

Both Lynx and Camelopardalis have considerable observational interest. Surprisingly, in dark skies there is even a star cluster in Camelopardalis distinctly visible to the naked eye — the compact 5.3 magnitude NGC-1502. However, in all of the huge expanse of Lynx, there are only two stars brighter than 4th magnitude, and the offerings of Camelopardalis are even dimmer, with a *lucida* — brightest star — of just 4.1. It is certainly not surprising that neither of these constellations is of ancient origin.

The origin of Lynx is well documented and amusing. Johannes Hewelcke, the man who first outlined the constellation, remarked that you had to have the eyes of a lynx to observe it. He was a fascinating figure in the history of astronomy — if you've never heard of him it's possibly because he is better known as Johannes Hevelius. Among his noted accomplishments, Hevelius named seven of the constellations visible from North America.

If you refer to a variety of books, you will find many people who claim to be the inventor of Camelopardalis. A dependable source states that the originator of this constellation was Petrus Plancius.

Camelopardalis (sometimes called Camelopardus) is so named because Europeans pictured the giraffe as combining the physical attributes of camel and *pard*, an archaic word for leopard. Although the lynx is derived from Hevelius, R.H. Allen says that Lynx has also been called Tigris — "from the fancied resemblance of the many little stars to spots on the tiger." But tigers have spots no more than bears have long tails.

There is no listing of accepted star names that includes any star in Lynx. Yet, there is one name clearly given by Allen. The name is *Alsciaukat*, which comes from the Arabic Al Shaukah (the thorn) applied by Assemani to the star 31 Lyncis, magnitude 4.3. This star lies on a line drawn from Castor to Iota Ursae Majoris, but it is much closer to the latter.

Many observers try to check off as many deep-sky objects as possible. For a change, try finding *all* the constellations visible from your latitude. Unfortunately, light pollution not only diminishes the bright constellations and the splendor of the starry sky as a whole, but also destroys some fainter naked-eye constellations by rendering them invisible. If you have a chance to observe in dark skies, look for the long line of Lynx lying across the path that takes your eye from Auriga to the nose of Ursa Major. The tall, straggling form of Camelopardalis lies between Auriga and the North Star, or between Cassiopeia and the nose of Ursa Major.

Dealing with Lynx and Camelopardalis raises the questions of which constellation in all the heavens is least conspicuous, and which is least famous. Neither of these questions is easy to answer statistically, but I recall having a constellation naming contest with a friend years ago in which — though both of us were unable to think of a few of the constellations from memory — we both missed only one in our independent listings: Circinus, the mariner's compass. This is a small group right next to Alpha and Beta Centauri — surely most southern hemisphere observers would not miss it in a naming contest.

What about the other question — what is the least conspicuous constellation? One way to answer that is to identify the constellation with the faintest lucida. The answer is Mensa, the table mountain, whose brightest star is magnitude 5.1.

ASTRONOMY
IN FOCUS

La Palma Observatory

Sir / I wish to correct "Ghostly Drummers and Zenith Tubes" in the December 1981 issue of ASTRONOMY, where it gives Las Palmas as the new home for the Isaac Newton telescope:

The correct location is La Palma, the island, not Las Palmas, the capital city of the Canary Islands.

I would also like to add that the Isaac Newton originally had a 98-inch mirror. It is being fitted with a newer, more powerful 100-inch mirror that will allow it to gather star images from the very deep universe.

The Isaac Newton telescope will be joined by a one-meter scope, and both should be operational by 1983. In about five years the 164-inch British-built telescope named after William Herschel will be added to the collection. This will make the La Palma location one of our best windows on the universe.

M.T. Chander
London, U.K.

Editor's note: The change from La Palma (which appeared in the original manuscript) to Las Palmas was made by a scrupulous but geographically misguided editor.

Astronomy for All Ages

Sir / The article by Harlan Ellison (Forum, August 1981) is so super and very special. What a fun sense of humor!

I am a 65-year-old retired school teacher. My father was a science professor in a south Texas college in the '30s and '40s, and he used to take us kids out at night to look at the stars through a borrowed telescope. We slept outside to watch the meteors — sometimes running into the house covered with ants! If only I had had the mathematical ability to match the interest, I would have loved so much to become an astronomer.

At present, I am helping some Vietnamese children — the young boy is fantastic at math. I have the whole family interested in the universe and we're going to the Griffith Observatory this Friday — they can hardly wait. (Me, too!) Julia, the 7th grader, won first place for her Halley's Comet project — "Snowballs in Space," she called it.

W. Irvine
Los Angeles, CA

Extrasolar Planets

Sir / With regard to David Finley's article (December 1981) on extrasolar planets: Current photographic plate technology *is*, indeed, able to locate the tiny wobble for many systems, and Sproul Observatory has not given up the search for extrasolar planets. In fact, though the Sproul findings have yet to be confirmed by another observatory, they have identified at least four stars that are likely to have planetary systems — CC 1228, Ci 2354, EV Lacertae, and Barnard's Star.

Of 46 stars or systems known to be within five parsecs, about half have been under 40-year surveillance by the Sproul Observatory. The remainder are too far south, too faint, or too recently discovered. If we eliminate the known double stars, we have fewer than 20 prime candidates for planetary companion analysis. Better than half of these show no periodic wiggles — in some cases down to levels below 0.01 arcsec — and this rules out the possibility of planets down to one Jupiter mass.

No observatory in the world has a collection of plates that matches Sproul's. Since the acquisition of a modern electronic measuring machine ten years ago, over 60,000 plates on many long series have been measured — evidence of the high stability of the 24" Brashear refractor. The telescope's ability to detect small perturbations caused by stellar companions has been independently confirmed by other observatories. There was a minute shift caused by lens adjustment and repositioning in the mid-1940s, but we are now routinely able to identify this simple shift (which does not occur in the Y-coordinate) and compensate for it.

Admittedly, the stellar perturbations are extremely small, and other factors enter which may mean the deviations are caused by very-low-mass stars, or even random error. It is only normal, when pushing scientific investigation to the limit, that questions arise and misinterpretation is possible.

While new technology will help astronomers identify extrasolar bodies more positively, the persistent generations of Sproul astronomers have already pointed out the very best places to look.

Elliot Borgman
Sproul Observatory
Swarthmore, PA

A Job Well Done

Sir / I have been a subscriber to ASTRONOMY for three years now, and in truth, I have thoroughly enjoyed your magazine during the whole time. Your claim to be "The World's Most Beautiful Astronomy Magazine" is certainly true.

But I am writing today to congratulate your entire team on the December 1981 issue of ASTRONOMY. In my opinion it is the very best of many outstanding issues.

Robert Burnham's article on the saturnian moons is a well-organized and informative summation of the data. I'm sure that many readers will agree that finding out so much about so many moons so fast can be utterly confusing. Mr. Burnham did a most commendable job of sifting through the onslaught in writing his easy-to-read report on this fascinating subject.

Fred Schaaf's story, "The Next Supernova," was thought-provoking and uplifting to those of us interested in such astounding subjects. Let us hope his estimates are accurate.

"The Planetarium: A Cultural Dinosaur?" was an important discussion. David Rodgers did a superb job dissecting the problems of the planetarium, an institution we all care about, and which we hope to see survive.

Finally, David Finley's Stellar Frontiers on searching for extrasolar planets was a fine account of an increasingly popular researched topic. This particular article strikes home for me because some of this very work is being done at the Allegheny Observatory in Pittsburgh, practically in my backyard!

Once again, I believe this issue to be outstanding — a cut above the rest. It is comforting to see that ASTRONOMY is not just good, but is becoming better and better.

Good luck for years to come, and a hearty congratulations for a job well done.

Dr. D.T. Wagner
Glenshaw, PA

Planetariums Survive

Sir / David A. Rodger's "The Planetarium: A Cultural Dinosaur?" in the December 1981 ASTRONOMY cries out for a response.

I have worked in a school planetarium for thirteen years. While Mr. Rodger untactfully uses his "Herr Professor" approach to the history of the planetarium, a few things about the planetarium concept ought to be established.

First of all, the planetarium cannot compete with Hollywood for special effects. But the planetarium is a teaching tool, with no attempt to commercialize.

Secondly, planetarium educators have been aware for a long time that the planetarium would not be the tool used for the instruction of advanced students. That it is a marvelous tool for the young and the scientific laity has been known for a long time. Think of it. Doesn't that cover a large percentage of the population?

Moreover, the aloofness apparently present in planetariums at one time no longer exists. With the growth of I.P.S., I seem to continually be bombarded with programs to share, ideas through workshops, concepts of planetarium usage to explore. The modern planetarium is a viable, changeable entity.

All ages find their way into our place. We visit classrooms, share ideas, use the blackboard. With this concept, the planetarium is not a magical place; it is an extension of the classroom itself, where ideas are shared, concepts are born, and chalk is used.

Richard J. Bernardo
Planetarium Director
Somerset High School
Somerset, MA

— Please re-read the Forum article. Mr. Rodger, former Director of the MacMillan Planetarium in Vancouver, clearly loves the planetarium. He would like to see them flourish — despite their determined efforts to fail.

Kitt Peak Observatory Saved

Sir / Official word has been received that the Air Force and Arizona Air National Guard have decided to conduct operations at Libby Army Airfield, Sierra Vista, Arizona, rather than at the originally preferred site near Three Points, Arizona, in the Altar Valley very close to Kitt Peak National Observatory.

On behalf of the astronomical community that uses the Kitt Peak National Observatory and also on behalf of the University of Michigan, Massachusetts Institute of Technology, Dartmouth College, and Case Western Reserve University — all with observatories on Kitt Peak — I would like to thank you for your efforts on our behalf.

Geoffrey Burbidge, Director
Kitt Peak National Observatory
Tucson, AZ

— We'd like to pass along a lot of the credit to our readers who wrote letters and otherwise made public officials aware of the importance of our national observatory.

Wonderful Hobby

Sir / I have been making reflecting telescopes for 50 years — many of them are still in use. 'Tis the most wonderful hobby anyone ever had.

I attended the Stellafane meeting in Springfield, Vermont, years ago, and I just want to thank you for writing about it. It's good to see it's still going on.

Am 92 years old now. My eyesight is very poor — but I can still dream and thank you people in Milwaukee.

Brice Dickson
Gastonia, NC

behind
the scenes

AstroNews Calendar

For many people, the contacts and friendships built through astronomy clubs, amateur meetings, star parties, and societies such as the AAVSO, ALPO, IAPPP, IOTA, and the Astronomical League are an essential part of the hobby of astronomy. Yet all too often, newcomers simply don't know where to go to find other people interested in astronomy.

To help remedy this situation, we're adding a calendar of upcoming events to AstroNews listing events of national or regional interest to amateur astronomers. Each entry will give the date, the name of the event, the organization, and the name and address of a person to contact for more information. If your group is holding such a meeting, please send us the information well in advance of the meeting date. That way, we can get your event into the calendar in time to do some good.

That's the national and regional level. On the local level, read AstroMart to find where and when astronomy clubs near you meet. We urge all clubs to send us an announcement of meeting times and places about twice a year. The initiative must be yours each time — we don't repeat announcements automatically.

We're also listing some meetings for professional astronomers in the AstroNews Calendar. While such meetings are not always open to the public, we think you'll be interested in where and when astronomers do meet — just for the fun of knowing.

Sincerely,

Richard Berry

Richard Berry
Editor

NUMBER TWO IN A SERIES OF TECHNICAL COMMUNICATIONS (OPTICS, PART 2)

LIGHT BAFFLES IN A CASSEGRAIN TELESCOPE

2

The Oversize-Primary-Mirror Claims Evaluated!!

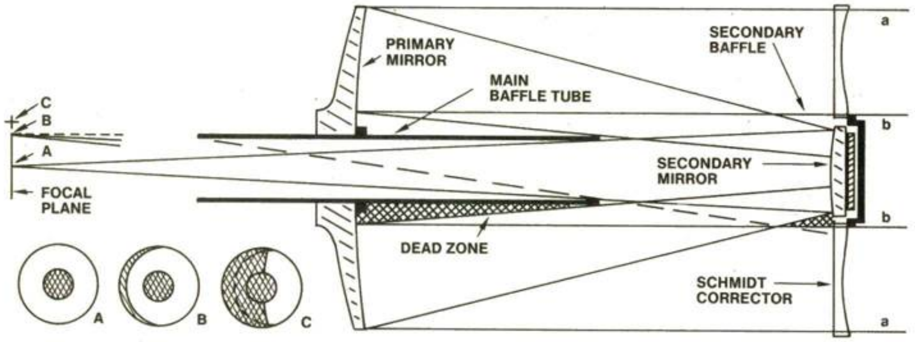


FIGURE 1.—Scale drawing of the Celestron 8 mirror and baffle tube arrangement. The cross-hatched areas of the drawing show where light baffles may be placed without interfering with on-axis rays. The circles at the lower left show the shadowing caused by the baffle tubes off-axis. (A) on axis, (B) corner of 35mm format, (C) 0.69° off axis.

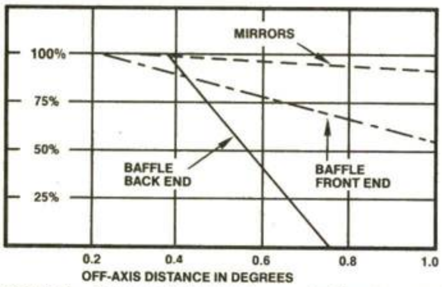


FIGURE 2.—Computed light fall-off caused by the primary and secondary mirrors combined. (a) the forward end of the primary baffle tube, (b) the rear end of the baffle tube.

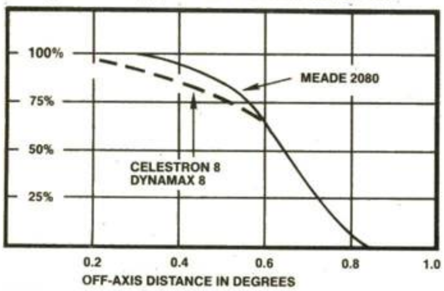


FIGURE 3.—The actual off-axis illumination of a Celestron 8, Dynamax 8 and a Meade 2080. Note that the Celestron 8 and the Dynamax were so close that they were plotted together. Also, note that the drop-off of all three systems confirms that the baffle tubes introduce the only measurable off-axis light drop-off of these systems.

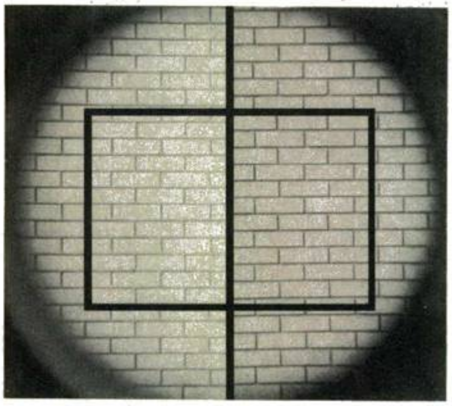


FIGURE 4.—Low-contrast field comparison shots on 6 x 6 cm format taken with the Meade 2080 (left) and the Celestron 8 (right). Note that there is no detectable drop-off in either system within the 35mm format (overdrawn). The stray light outer ring of the Meade photo was apparently caused by inadequate opaquing of the baffle tubes.

Considerable confusion has been stirred up among would-be telescope purchasers by some advertising relative to the effect of off-axis illumination that can be achieved by using an oversize primary mirror in an 8-inch Schmidt-Cassegrain telescope. We respectively suggest that a computation be made of the actual amount by which the outer rays are deflected outward. We have and it is 0.008 inch on the primary mirror. The 0.060 inch by which the Celestron mirror is oversize fully catches all of these outer rays. What our competitors overlook in their advertising is that the light fall-off at the edge of the field caused by either the primary or secondary mirror is insignificant compared to that caused by the baffle tube system.

The Celestron 8 was thoroughly engineered for optimum performance in regard to off-axis illumination and light baffling. The baffle system prevents any unfocused light that may bypass the secondary from arriving at the focal plane. With the exception of certain minor modifications, competitive Schmidt-Cassegrain telescopes are substantially the same. Any improvement brought about by these minor modifications is questionable.

LIGHT BAFFLES FOR CASSEGRAIN TELESCOPES

Figure 1 is a scale drawing of the mirror placement and baffle tube arrangement of the Celestron 8. The variables at the designer's disposal in arriving at an optimum design are: 1. Primary and secondary mirror sizes; 2. Diameter and length of the primary baffle tube; 3. Diameter and length of the secondary baffle tube. The first step in designing the light baffle system for a Cassegrain telescope is to make a scale drawing of the mirror placement of the proposed system. Two sets of lines representing the outermost rays (a) and innermost rays (b) are drawn through the system. It will be noted that a dead space (no light rays present) is defined by these sets of lines. This is shown cross-hatched in Figure 1. It is in this space that the light baffles may be placed. Since it is only necessary that unfocused light be prevented from arriving at the focal plane by these baffle tubes, the baffles need not extend to the maximum available space. Having established a proposed light baffle system, the off-axis performance for a given set of mirror sizes may be readily evaluated.

Figure 2 is a graph which shows the effect on off-axis illumination of each of the several factors which influence off-axis illumination of the Celestron 8. It will be noted from this figure that the light drop-off caused by the primary or secondary mirror is negligible when compared to that of the baffle system.

The inside diameter of the primary baffle of the Meade 2080 and the Dynamax 8 is the same as in the Celestron 8 (1.5 inches). Therefore, the abrupt light cut-off as caused by the rear end of the baffle tube is the same in all three systems. In the Dynamax 8, the primary baffle is ½-inch longer than the C8. Therefore its light fall-off would be slightly greater than the Celestron 8. In the Meade 2080, the primary baffle is 1.5 inches shorter, thereby increasing the 100% illumination 7½ arc minutes further off-axis than either the Celestron 8 or the Dynamax 8. This, however, results in stray light being present at the corner 0.2 inch of a 35mm format. This coupled with the inadequate opaquing of the baffle tube itself resulted in the Meade 2080 evaluated having considerably reduced contrast when used as a telephoto lens or for daytime terrestrial observing.

Celestron 8, Serial No. 811417; Meade 2080, Serial No. 800544; and Dynamax 8, Serial No. 710176, were each set up in a collimator and tested in regard to off-axis illumination. A sensitive photometer was used to make these measurements. Figure 3 is a plot of the test data taken. We leave it to you to conclude whether or not either the Meade or Criterion oversize mirror gives the superior off-axis illumination which they claimed.

Celestron®

Celestron International, 2835 Columbia St., Box 3578-B, Torrance, CA 90503 (213) 328-9560

how to plan a newtonian reflector

How often have you thought about building your own telescope — then abandoned the idea because it seemed too complicated? Well, if it's a Newtonian telescope you've been thinking of — cheer up! It's not difficult at all. Sure, there's a bit of math involved, but choosing the two mirrors of a Newtonian and assembling them into a telescope tube is straightforward.

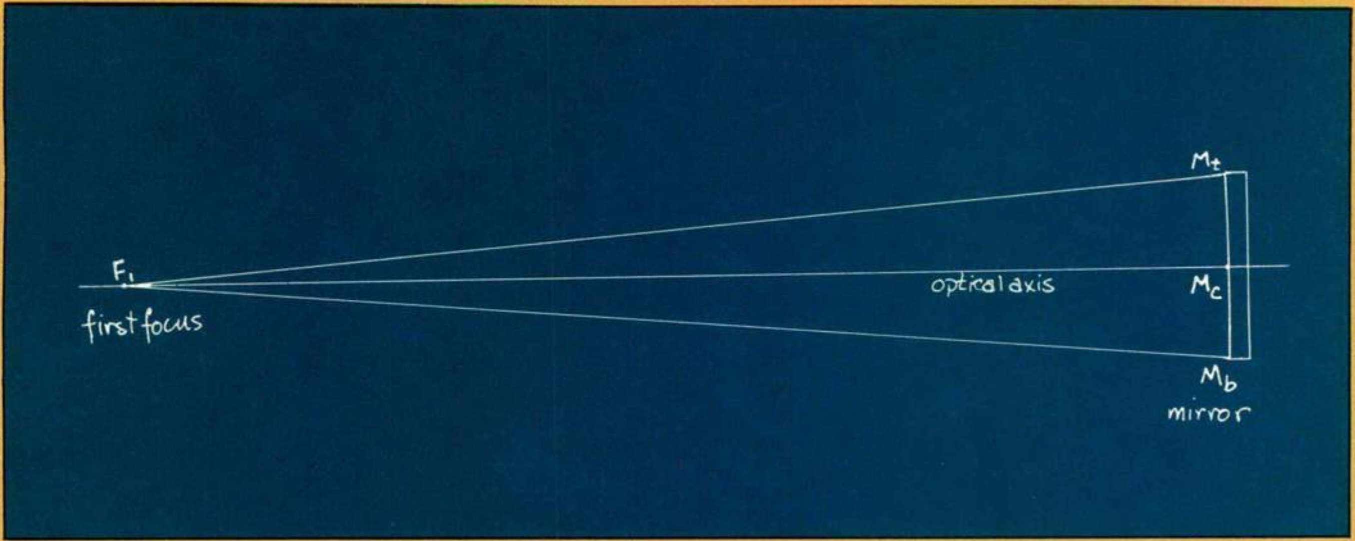
First a bit of background information: the optical part of a Newtonian reflector consists of two mirrors and an eyepiece. The larger mirror, or the primary as it's called, is the heart of the telescope. Its diameter — called the aperture of the telescope — and its focal length — the distance between the mirror and the image it forms — determine just about everything else about the telescope. The diagonal mirror is a small mirror that deflects the light from the primary into the eyepiece outside the telescope tube. The eyepiece is an optically sophisticated "magnifying glass" that you use to closely examine the image of the sky formed by the primary mirror.

The telescope tube, the "cell" that holds the main mirror, the "spider" that holds the diagonal mirror, and the focuser all serve to hold the optics in place — nothing more.

Step 1: Define the Telescope

On a sheet of paper, write down what you want from your future telescope. Forget, for the moment, how much it will cost, or what your friends have, and think about what you want to see with it. Planets, clusters, galaxies, the Moon, globulars, planetary nebulae, asteriods, comets . . . you name it. Now consider aperture: any

Newtonian reflectors are easy to plan. For a first scope, most builders choose a 6" or 8" aperture, if the mount will be equatorial, or 10" for a Dobsonian. Photo and telescope by Gerald Sibert.



telescope with four inches or more will give you a good view of the Moon. Six-inch or larger scopes will give you good views of the planets. You can find all the Messier objects with a 4-inch under dark skies. You can see details in most of them with an 8-inch. And they're pretty spectacular with a 16-inch. The brighter globular star clusters are nice in an 8-inch, but better in a 12-inch.

What's the bottom line? A 4-inch is a beginner's telescope. A 6-inch can do almost anything you might want for starters; an 8-inch is a good all-around telescope, great for a beginner; and a 10-inch is a "Cadillac" for a first telescope. Bigger telescopes should be second telescopes.

Step 2: Narrow the Choices

Now start to put constraints on your dream telescope. Where will you use it? How far will you need to carry it? How wide is the trunk or back seat of your car? How many pounds can you carry? How tall are you? How much money are you prepared to spend?

Most medium-size cars can readily accommodate a 48" tube across the back seat. Measure yours if you plan to go to dark sky sites with it. Carry a 25 pound bag of kitty litter (or whatever else is fairly handy and heavy) up and down the back stairs five times to get a realistic feel for what it's like lugging a telescope around. Don't kid yourself: if it's a pain in the neck to use it, you won't.

Let's say that 48" is a practical length for your telescope tube. As a rule of thumb, the length of the telescope tube equals the focal length of the mirror. That could mean a 6-inch f/8 mirror, an 8-inch f/6 mirror, or a 10-inch f/4.8 mirror — maximum. Shorter focal ratio mirrors will have shorter tubes.

Now look at the mirrors available. Your mirror has to be quarter-wave or better to perform well. "Quarter wave" means that the light, as it comes together to a focus, has no errors greater than ¼ the wavelength of light, or about 0.000005 inch. Optical manufacturers use a variety of methods to measure this. If you made your own mirror, you'd probably use the Foucault test, and calculate the "wave error" from a set of zonal test readings. "Null figured" means that the optician has tested the mirror's quality with a optical compensating lens — nothing more. Ronchi (pronounced RON-key) testing is yet another popular way of testing.

At this point, price may become a deciding factor for you. A 10-inch mirror could cost too much — but an 8-inch could fit right into your budget. Think about the cost of other components, too. The mirror will not be the only expense.

Step 3: Reach a Decision

Knowing the maximum tube length — and with the aperture limited by portability, weight or cost — you probably have one more question: What's the best focal ratio? Some people say a low f/number makes a telescope a low-power RFT, or a long f/ratio makes a high magnification planetary scope. However, it's not a terrifically critical decision. With different eyepieces, you can get suitably high and low magnification for both purposes with any mirror between f/4 and f/10. The need for portability will push you toward small f/ratios, the desire for high magnification toward higher f/ratios.

If you're going to buy a finished mirror, the f/ratio decision depends to some extent on what's for sale. The bottom line on this item is this: Choose the longest tube length you can (remember that tube length approximately equals focal length), and the largest aperture you can afford. Divide the focal length by the aperture — that's the optimum f/ratio for you. Then compromise by buying what's available — or pay a premium price for a custom job.

If you intend to grind, polish, and figure your own telescope mirror, be conservative about the mirror size. A 6-inch mirror is a good size for teenagers or adults with smallish hands. An 8-inch is quite practical for an adult's first mirror. A 10-inch mirror is a lot of work, and getting a good "wave rating" on the surface is tricky. A 10-inch or 12-inch mirror would be far more suitable for your *next* telescope.

By grinding your own mirror, you have complete control over the focal length. The box on the next page lists a number of firms that sell telescope mirror making kits.

Step 4: Choose a Tube

The tube of your telescope supports the optics. It can be an open strutwork or solid; square, round, or any polygon you want; and made from wood, fiberglass, bakelite, waterproofed paper, concrete construction form, rigid foam sheeting — whatever you want to work with. In general, you want a light material formed into a rigid shape. Square wooden tubes are excellent for telescopes, inexpensive, and easy to make. So are round fiberglass, paper, or bakelite tubes. Metal tubes aren't as good: they are heavy, and metal conducts heat too well, causing air currents that will distort your view in the optical path.

The smallest inside dimension of the tube should be at least an inch greater than the mirror. A two-inch clearance is better, especially for round tubes. This means your 8-inch mirror needs a 10-inch diameter round tube or a square ¼" plywood tube 9½" by 9½".

Step 5: Choose the Spider, Cell, and Focuser

You can construct a mirror cell, spider, and focuser yourself (see "How to Build a Dobsonian Telescope, Part 3," in the August 1980 ASTRONOMY) or buy them ready made. Many firms advertise these in ASTRONOMY. If you're buying ready-made components, make sure that they are compatible with the type of tube you have chosen.

Step 6: Plan the Optical System

Now it's time to get down to working out the nitty-gritty of the telescope. You'll need three pieces of information before proceeding: 1) the focal length of the mirror, 2) the racked-in height of the focuser, and 3) the diameter of the tube.

On a large sheet of graph paper or a roll of shelf paper, draw a full-size sketch of the mirror and the light coming to a focus from it. First draw the optical axis, a long, straight line. Draw the mirror near one end of the axis — use the full diameter and draw it the advertised thickness. From the center of its front surface, at point M_c, measure off the focal length along the optical axis, and mark the point as F_1. This is the focal point. Next, connect the top and bottom edges of the mirror — points M_t and M_b — with straight lines to the focal point.

Measure everything carefully; make sure your lines are straight and the right angles accurate. Here, at last, you are confronted directly with the size of the telescope you propose to build. If the reality is a little stunning, you can return to Step 2 sadder and a bit wiser.

Draw two lines one tube diameter apart — centered and parallel with the optical axis — from the point of focus back to the mirror. Label them T_1 T_1 and T_2 T_2. These lines represent the tube.

Draw another line parallel to the optical axis at a distance equal to the height of the focuser beyond the tube line. Label it HH. Draw another line, EE, one inch beyond that. The actual focal point of the telescope should lie somewhere along this line.

How far is the focal point from the optical axis? It should be half the diameter of the tube, plus the racked-in height of the focuser, plus one inch. Measure this distance toward the mirror from the focal point along the optical axis, and mark the spot D. This is the location of the diagonal mirror.

Construct a line perpendicular to the optical axis to line EE. The point of intersection, F_2, is the focal point of the Newtonian telescope. Now, double check that you've done everything correctly: the sum of lines DM_c and DF_2 should be equal to the focal length, or line M_cF_1.

Carefully construct a line at a 45° angle to the optical axis and line DF_2. This is the surface of the diagonal mirror. It intersects lines F_1 M_t and F_1 M_b at two points. Label them D_t and D_b, respectively. Now draw in lines F_2 D_t and F_2 D_b to complete the paths of light from the mirror to the Newtonian telescope's focal point.

Step 7: Find the Diagonal Size

You are now ready to determine the size of the telescope's diagonal mirror — but first you must decide on the diameter of the field of view. For 1¼" standard size eyepieces, a "fully illuminated" field of view ½" diameter is quite suitable for most people's needs. The edges of the field, which are somewhat less important, will be 80% to 99% fully illuminated. This small loss is not important.

Here is a simple formula for calculating the minor axis dimension of the diagonal:

$$a = d + (c/f)$$

In this formula, *a* is the minor axis, or short dimension, of an elliptically shaped diagonal mirror. (The major axis is 1.414 times longer.) The diameter of the fully illuminated field of view is called *d*. The distance from the diagonal to the point of focus, line DF_2, is *c*. The focal ratio of the mirror is *f*. For a 6" f/8 mirror, with $c = 7''$, the formula calls for a 1.38" diagonal. A diagonal as much as ¼" smaller, or 1.13", would still work perfectly well, though the fully illuminated field would be smaller.

mirror kits

The following companies are a few of those that sell kits which include glass blanks, abrasives, and pitch for making your own mirror.

Edmund Scientific Co.
101 E. Gloucester Pike
Barrington, NJ 08007

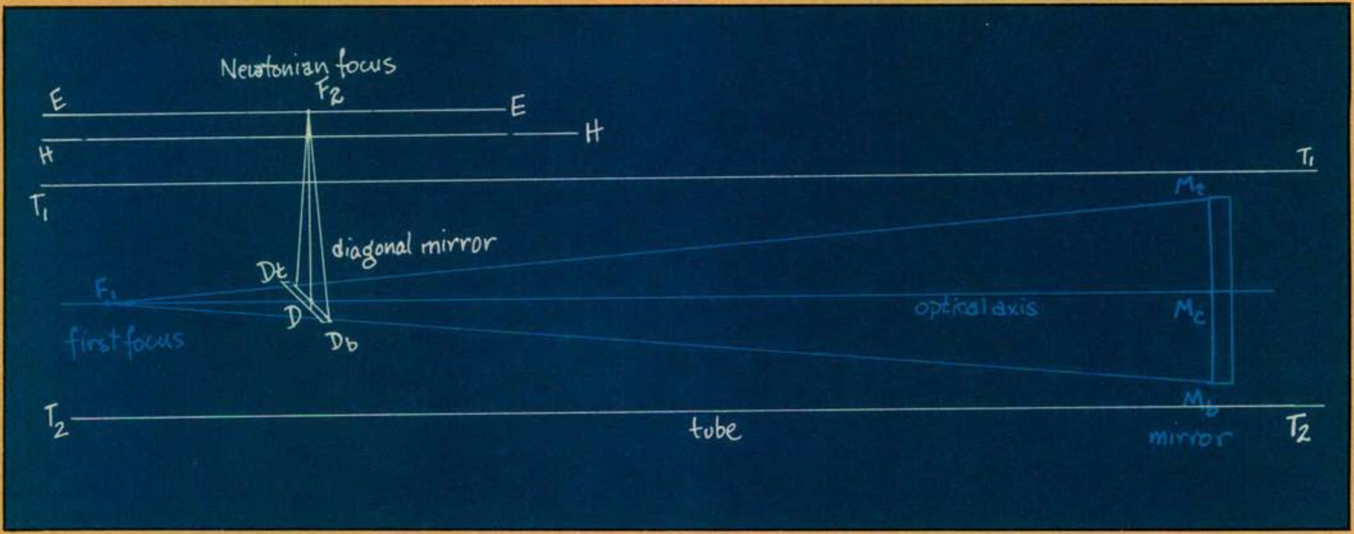
Willmann-Bell, Inc.
P.O. Box 3125
Richmond, VA 23235

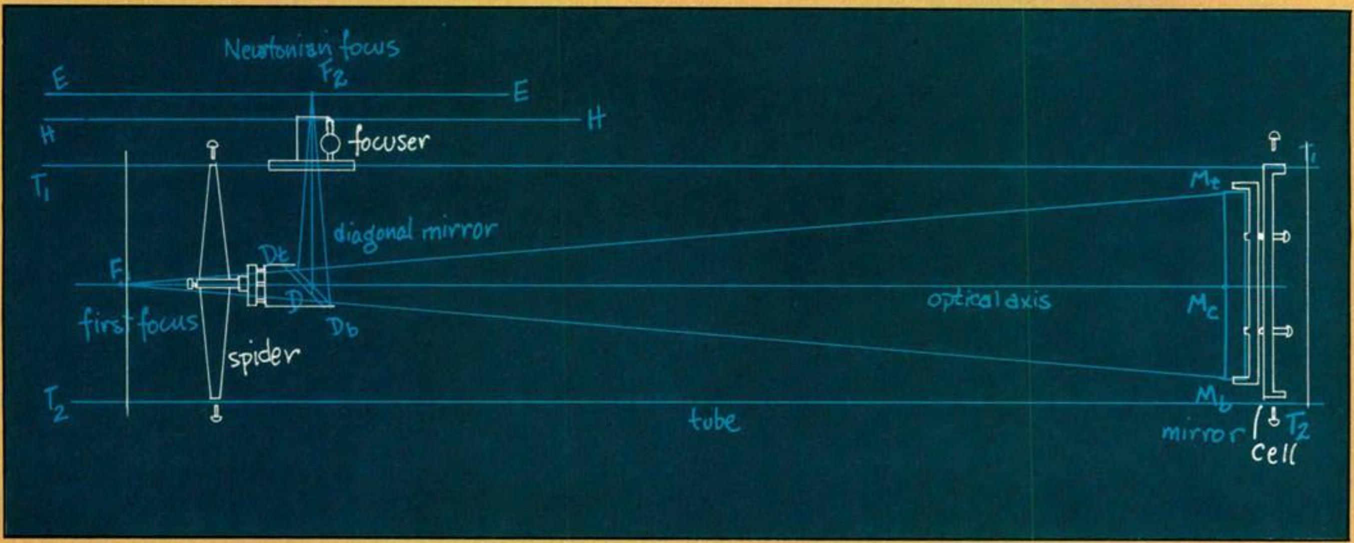
Optica b/c Co.
Astronomy Division
4100 MacArthur Blvd.
Oakland, CA 94619

Telescopics
P.O. Box 98
La Canada, CA 91011

As a general rule, you don't want to install a diagonal that's any larger than necessary. Not only does the diagonal block some light from reaching the primary mirror, although it's usually only about 5%, but it also decreases the contrast in high-power lunar and planetary viewing. The smaller the diagonal, the less the effect. If possible, the diagonal should be less than one-quarter the size of the primary, and preferably less than one-fifth its size.

By keeping the distance between the diagonal and the focus small, you'll keep the diagonal mirror small. "Low profile" focusers help you accomplish this. It's easier to keep the diagonal small if the focal ratio of the mirror is large. This is another reason focal ratios greater than f/8 are good for planetary viewing — especially because in planetary viewing, you can also lower





the value of *d* to as little as ¼".

For deep-sky observing with low-focal ratio RFTs, where you want a wide, fully-illuminated field, you'll find it's difficult to use a small diagonal. It's doubly difficult if you plan to do prime focus photography — you might want *d* = 1.00" for an f/4 mirror! If this upsets you, return to Step 3.

Step 8: Finish Your Drawing

Now it's time to add the diagonal holder, the spider, and the mirror cell to your drawing. If you don't actually have them, estimate as best you can from the manufacturer's pictures or spec sheets. Figure out where the bolt holes will come on the tube, and mark them on the drawing.

If you're building your own cell and spider assembly, now is the time to choose the dimensions of the parts.

Also draw in the focuser. Study the spec sheets carefully. You might want to consider getting an oversize 2-inch diameter focuser especially if you're contemplating lots of deep-sky observing with 2-inch eyepieces, or prime-focus astrophotography. If you change your mind, return to Step 6.

Finally, complete the drawing of the tube. Allow an inch or so from the bolt holes of the mirror cell to the bottom end of the tube. At the top end, allow at least one mirror-diameter of extra tube length beyond the position of the focuser. The extra tube will help block stray light.

Now measure the total length of the tube from the drawing. It should come pretty close to being the same as the focal length — within a few inches either way. If it's just a little too long to fit in the trunk or back seat of your car, consider reducing the extra length at the front of the tube. If it's much too long, you've made a mistake somewhere along the way.

Step 9: Choose the Eyepieces

Most people buy their eyepieces as an afterthought. You shouldn't; they're an important part of the optical system. Most observers need a low-power eyepiece, a medium-low power eyepiece, a medium-high power eyepiece, a high-power eyepiece, and a very-high power eyepiece — in that order. You certainly don't need them *all* to start out. Now, set up a table of eyepieces.

First, find out the actual magnifications your intended telescope can deliver. Multiply the aperture in inches by the following to obtain the power:

- for low power multiply by 4 to 5
- for medium-low multiply by 6 to 9
- for medium-high multiply by 12 to 18
- for high power multiply by 25 to 40
- for very-high power multiply by 50

For example: a 6-inch telescope should have a low magnification of about 28, a medium-low magnification around 45, a medium-high magnification of 90, and so on, to a maximum of about 300x. You'll probably be surprised at how small the numbers look — but that's only because telescopes are all-too-often rated by the very highest magnification they can deliver, rather than the more moderate and practical powers most observers actually use.

Now, compute the proper focal length for each eyepiece. Because eyepieces are sold in metric focal lengths, convert the focal length of your mirror to millimeters (multiply inches by 25.4 to get mm). Example: a 48" focus mirror has a focal length of 1220mm.

Next, for each eyepiece, divide the focal length of the telescope by the magnification it should give. For the medium-low power eyepiece on a 6-inch f/8 telescope, divide the 1220mm focal length by a magnification of 45 to get a 27mm focal length eyepiece. Look at the ads; there are plenty of eyepieces with focal lengths near that: 30, 28, 26, and 25mm for example. For the medium-low power, you'll need a 10 to 16 millimeter focal length — for medium-high, 6 to 8mm focus, and so on.

Now go back to the advertisements and see what's available. For deep-sky observing, wide-field eyepieces such as Erfles are very nice. For planetary, you need crisp images. If you're on a budget, choose budget eyepieces — or settle for just one or two that are more expensive.

Be prepared to "horse-trade" with your magnifications. To get high magnification for planetary and lunar observing, it's often best to choose a long-focus mirror. But you may prefer a short-focus mirror for low-power deep-sky observation. For example, with a fairly large focal ratio telescope, you may not be able to find a low-power eyepiece — the best you can do might fall midway between low and medium-low. Fine — there's nothing wrong with 35 power — but try to space the powers out fairly evenly. Once again, if the results don't please you, return to Step 2.

Step 10: Ready to Go

Once you have a firm grip on what you want from your telescope, how big it's going to be, how long it's going to be, what magnifications it will produce, and what eyepieces you want — total it all up. Add up the cost. Add up the weight. Add up the capabilities.

Now answer these questions: Can I afford it? Will it fit down the back hall stairs? Where will I keep it? Will it be big enough for the kind of observing I really want to do? Have I thought about the mounting yet — equatorial or Dobsonian? If it's equatorial, what kind of equatorial do I want? If you're not happy with the answers, return to Step 1. Now you know more than you did before. It's a learning process.

No telescope can completely satisfy any observer all the time. But if you've made all the compromises properly, then you're ready to go.

— *Richard Berry*

In the enormous emptiness of our local Universe there are one hundred billion stars: A star for each human being that has ever lived! Is there anyone out there...or are we alone? No one knows, but we can begin to look for signs of extraterrestrial intelligence by eavesdropping on the radio communications that they may use.

NASA's **S**earch for **E**xtra**T**errestrial **I**ntelligence (SETI) Program is designed to do just that, but the **P**olitical **E**ar**T**h **I**ntelligence just cut all the funds for SETI research. Are we intelligent enough to conduct a SETI program? Delta Vee, home of the Viking and Halley Funds, thinks so, and in response to public demand announces its Extraterrestrial Connection (DVEC): a public fund aimed at financing NASA's SETI program. Delta Vee, using its Viking Fund precedent, will contract with NASA for actual SETI observations of stars and for the upgrading of data processing equipment.

As incentives to contribute to its Extraterrestrial Connection, Delta Vee has arranged for several exciting enticements:

- *All contributions will be recorded on a microfilm scroll to be placed on the improved data processing equipment when it is built. All contributors will be invited to the dedication ceremony. All contributors will also receive Delta Vee's quarterly "UPDATE."*
- *All **$100** or more contributions receive NASA's Report #SP-419 on SETI.*
- *In addition, all **$400** or more contributions will have assigned to their name a particular star and search frequency by DVEC and NASA's SETI program. Each contributor at this level receives a special print out of their star's characteristics and search description. IMAGINE IF AN INTELLIGENT SIGNAL IS RECEIVED FROM THE STAR THAT IS ASSIGNED TO YOU!*
- *All **$900** or more contributions receive everything that the $400 contributor gets, PLUS a beautiful star chart, suitable for framing, with their star circled.*
- *All **$2001** or more contributors receive everything described above, but in addition the $2001 + contributor receives a very special mystery gift.*

*(allow 6-8 weeks for receipt of your special gift)

So don't delay the search! Demonstrate your Earthly intelligence to Washington D.C. and help pay for SETI at the same time. Whether the search is successful or not, the consequences for humanity are indeed profound, and you can play an important part in such a history making endeavor.

Mail your tax deductible contribution to:

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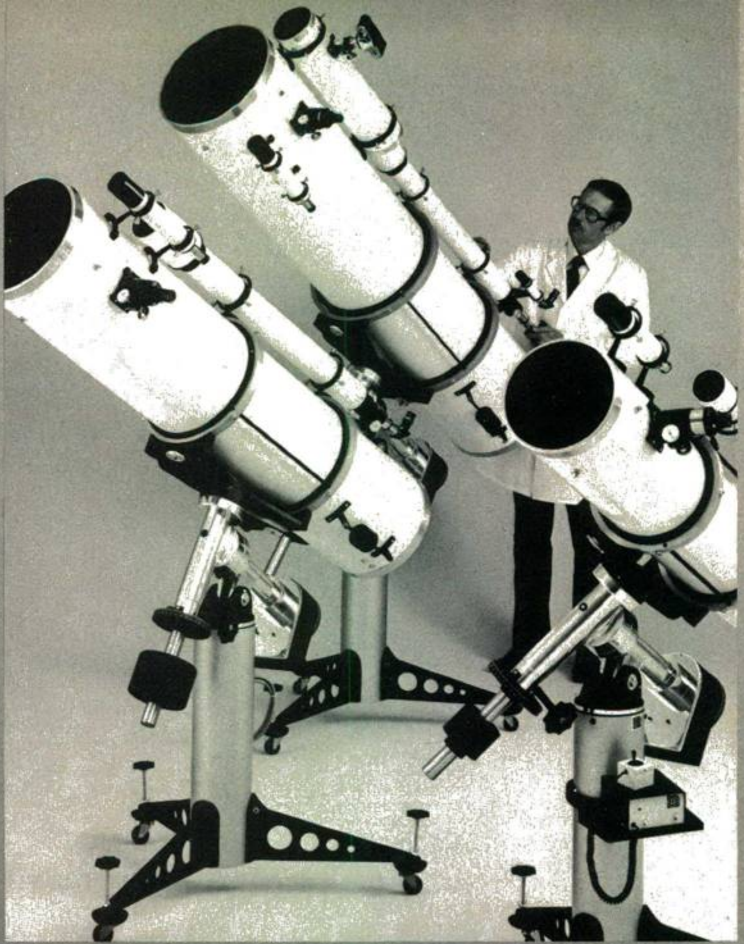

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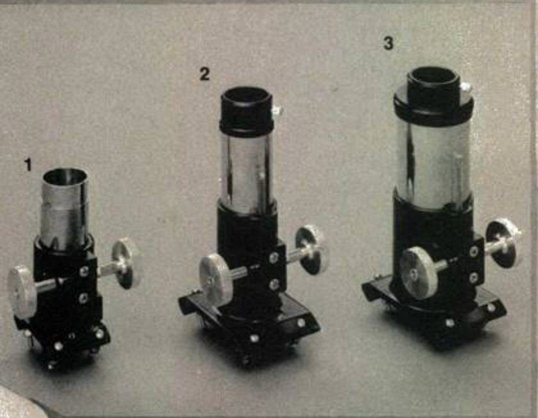

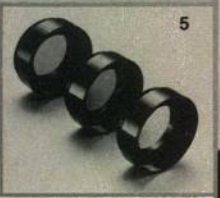

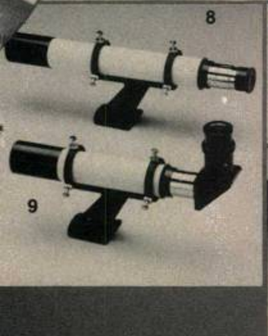

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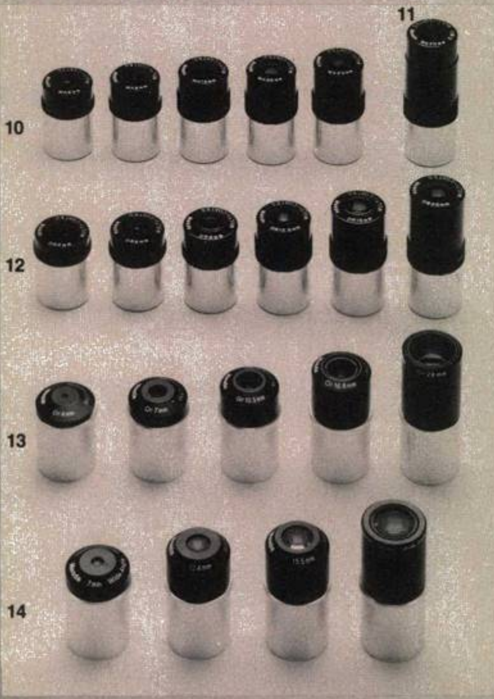

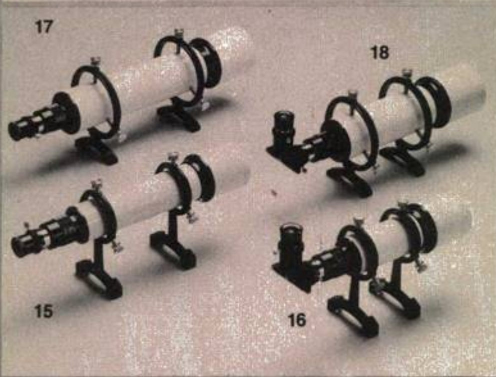

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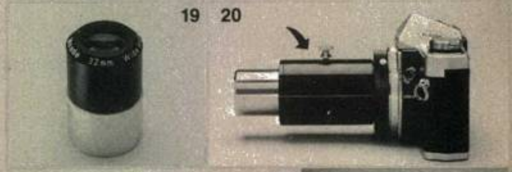

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gazer's
gazette

watch the skies

by
John Mood

Last month in the opening section of "Watch the Skies," John Mood examined the basic visual effects of atmospheric optics. In his conclusion this month, he discusses the more complex displays.

Halos are not to be confused with aureoles, coronae, and related phenomena caused by diffraction. This "distortion" of light is different from the four basic effects that occur in relation to opaque matter rather than transparent or translucent matter. In other words, light cannot go through but has to go around, and thereby creates unusual and beautiful effects.

An aureole is a small fuzz of light adjacent to and around the Moon. It can also occur around the Sun, but the brightness of the Sun usually washes it out, although with careful viewing you can actually see it rather frequently. It is as if the Moon were placed in a round glowing pillow of pearly soft light. It can appear and disappear quite rapidly as my wife learned once when she ran upstairs to get her camera. By the time she came back out less than a minute later, the aureole was completely gone. Aureoles can also last for hours. Caused by intervening clouds (thus diffracting the light), the effect can be breathtaking in its beauty. They can be faintly colored and can also occur around the brighter planets and stars on occasion. Last year I saw Venus with scintillation spikes (twinkling effect) surrounded by an aureole — it looked like a brilliant perfectly round white pearl with a sparkling diamond embedded in it, or like a heavenly star sapphire spotlighted in a soft circle of light against the velvet black sky. It wasn't a good evening for telescopic viewing, but who cares with a treat like that?

Another diffraction phenomenon is a corona around the Moon. Don't confuse this with the Sun's corona, which is part of the Sun itself and visible only during a total eclipse. A corona around the Moon is an effect of the Earth's atmosphere only, and consists of a series of small delicate rings outside the aureole, or in place of the aureole. Sometimes the rings can be colored quite brightly. They should not to be confused with ice crystal halos, either, since they are smaller in circumference and much thinner. Minnaert reports detecting a yellow-green aureole around the Moon, with a broad red corona outside, and thin blue and green rings outside that.

As with other displays of atmospheric optics, the corona can change dramatically in a short period of time. I recently saw one around the Moon which began as an aureole, then formed a corona, brightened, detached itself from the aureole, became banded, and then took on definite shades of color all within a matter of minutes. At no time did the display remain constant; the changing vista continued in a state of flux until it gradually faded to a faint aureole again. Averted vision helped me detect the colors.

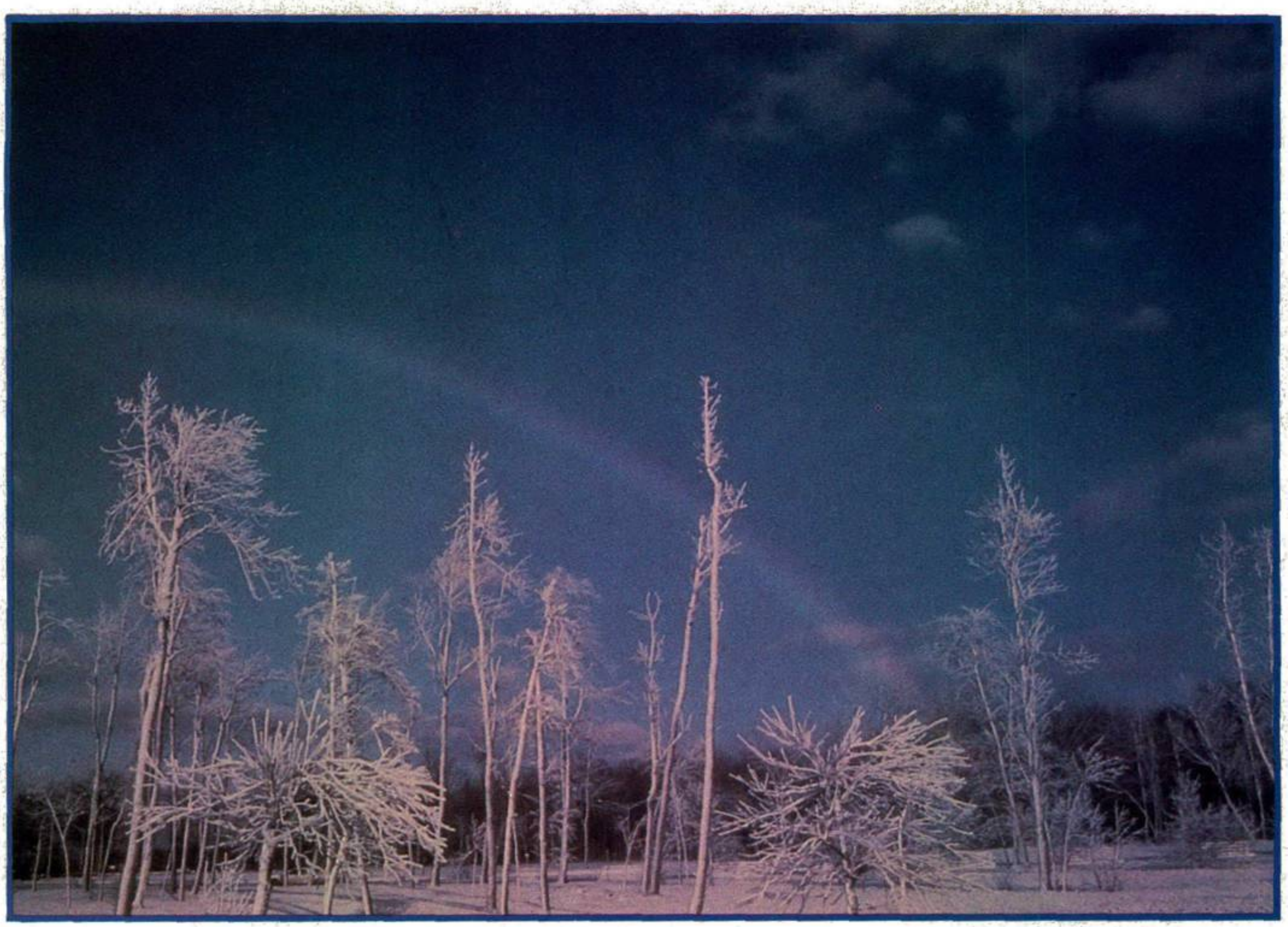
> **"Watch the skies!"**
> Voice-over at the end of
> *The Thing from Another World* (1949)

Some of these phenomena occur in combination. The most frequent is a 22° ice crystal halo around the Moon which is itself surrounded by a glowing fuzzy aureole.

The Moon and the planets sometimes produce combinations of effects. You can, on occasion, see the planets surrounded by their own aureoles, resting inside the 22° halo around the Moon. I saw this once with Jupiter and Mars, and recently with Jupiter just inside the 22° halo. Watch for this breathtaking sight each time the Moon gets within twenty-two degrees of Jupiter and Saturn over the next few months — the Moon fuzzed with aureole and surrounded by a complete 22° halo framing Jupiter and possibly Saturn — which are also delicately aureoled. This entire picture will gleam in the soft night sky.

Another phenomenon of atmospheric optics is the rainbow. We are all familiar with this, but have we yet learned to really see what we are looking at? Have you noticed, for example, that violet is invariably inside the rainbow and red outside? That the sky is brighter inside than outside the rainbow? That the thickness of the rainbow can vary sharply, and quickly? Did you know that if you stand with your back to the Sun and measure the angle between where the shadow of your head falls on the ground and any point on the rainbow, that angle will always be 42°? And did you know that rainbows are coused by a combination of reflection and refraction?

Have you ever seen a secondary rainbow outside the primary? The secondary always has its colors inverted — red inside, violet outside, and is always at a 51° angle. Sometimes, the sky is brighter outside the secondary than between the primary and secondary rainbows. Have you ever seen the "spurious" rainbow, more properly called the supernumerary rainbow, under the primary rainbow? You can also occasionally see red rainbows shortly before or even after sunset, caused by diffraction and/or scattering of light in the atmosphere. White rainbows caused by fog or mist are also nice sights, but wider than regular bows. These sometimes show faint orange outside and faint blue inside. Diffraction produces these phenomena, as well as dew bows on misty ground or over the surface of a lake. Reflected-light rainbows and



This frozen scene features an unusual winter rainbow formed by super-cooled water droplets in an otherwise clear sky. Robert Greenler took the picture near Niagara Falls when the spray had not yet had time to to freeze.

Moon rainbows are other occasionally glimpsed sights.

Rainbows, then, are not as simple as you might first expect, and can provide many fascinating sights, if you take time to learn to look carefully.

Again, you can watch for unusual, complex displays. I recently observed a brilliant rainbow with a bright secondary bow outside, and two faint green and blue supernumerary bows inside that created the appearance of two white bows inside the primary. So on rainy days, keep your eyes open — that is, *engage in astronomical observation.*

Rainbows are always caused by droplets of water whose sizes determine the thickness of the bow. They can be observed as closely as only a few feet away, as any child running through a water sprinkler on a summer day can attest. If you've ever seen a rainbow during snow, you may be quite certain that some of the snow has turned to watery mush in the sky, because, as we've seen, snow (ice crystals) causes halos and arcs, not bows. Scientists have mastered the physics of the rainbow, even to the extent of precisely determining the various sizes of the drops necessary for the different rainbow variations in width, color, and number of secondary or supernumerary bows.

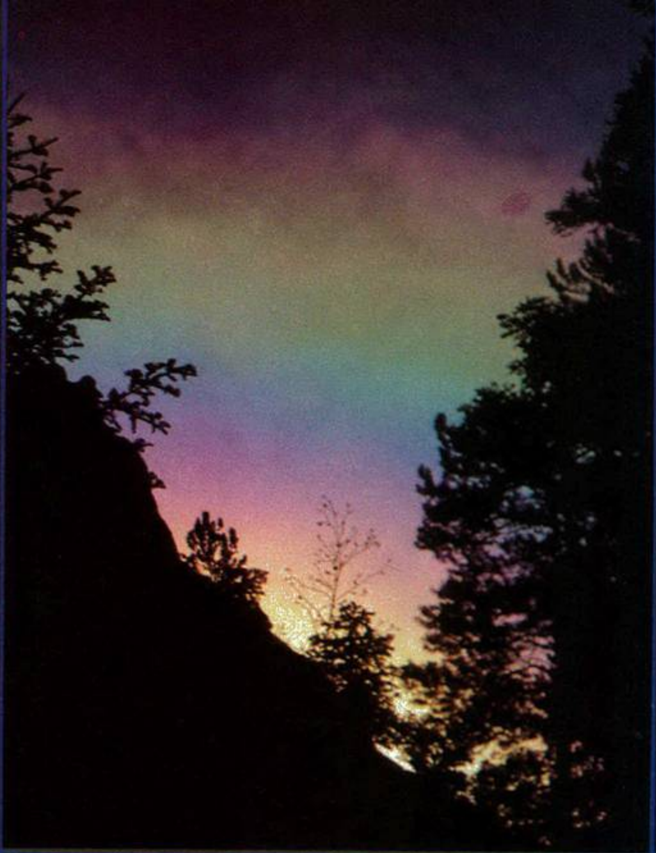
Another common diffraction phenomenon is the heiligenschein (pronounced "HIGH-leh-gen-shine"). It is a bright halo of light seen around the shadow of one's own head on, for example, a dewy lawn. The sixteenth century artist Benvenuto Cellini saw one around his head and thought it a divine sign of his chosen genius. The word comes from German meaning "holy light." Cellini's precise words were, "Ever since the time of my strange vision until now an aureole of glory (marvellous to relate) has rested on my head." You don't have to be a genius to see a heiligenschein around your head. It is a common sight for bicyclists out on an early morning ride. The singular feature of the heiligenschein is that you can see it only around your own head.

"We must be outside!"
Jessica on seeing the Sun rise.
Logan's Run
(1978)

To demonstrate this, R.A.R. Tricker took a photograph of a heiligenschein around his head with none around the shadow of a companion standing nearby; then matched it with a photo of a heiligenschein around a camera, with none around the photographer standing beside it.

The glory is another diffraction display, best viewed from heights. Before the days of everyday jet flight, it was a rare phenomenon, but now can be seen frequently. The glory is a colored corona, and is usually accompanied by a mistbow. It is, in effect, a corona around oneself or one's airplane. Looking for it can be an enjoyable astronomical pastime during flight. It's certainly better than most of the onboard films you can see. And it's real!

Additional diffractions may strain your credulity but do, in fact, exist, as reported by quite reliable observers. Rare sights like a green Sun or a blue Moon ("once in a blue Moon"), as well as more common effects like colored iridescent clouds, or mother-of-pearl clouds (nacreous clouds) are not mythological fancies or the results of hallucinations, but are real effects of the atmosphere on light. The same is



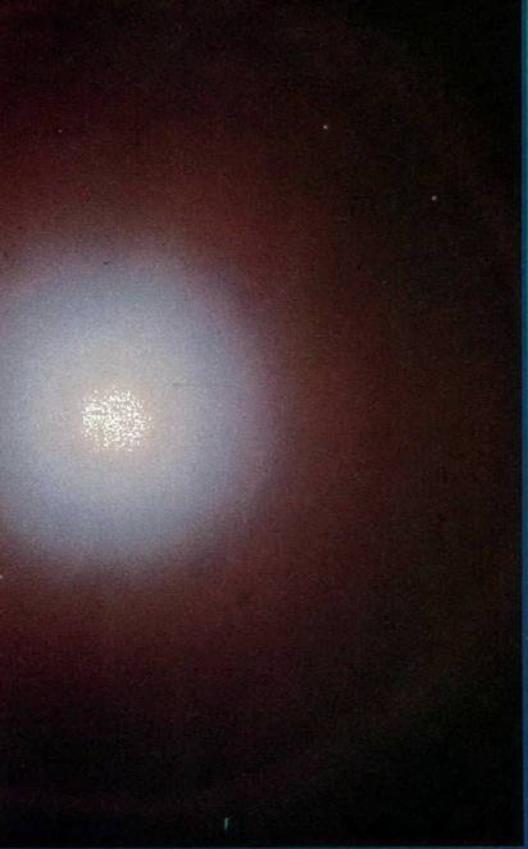
true of such fabled phenomena of the bending of light as mirages — inferior (downward, the desert effect), superior (upward, and lateral). Then there are the *fata morgana* or castles in the air — no myth but a real optical phenomenon, actually and frequently photographed. Other effects include: shadow bands, the specter of the Brocken (a version of the glory), the Novaya Zemlya phenomenon (Sun appearing visible while still actually below the horizon), scintillation (twinkling), and dazzling (too bright light).

So the amount and kinds of astronomical observations you can participate in during the daytime without any equipment other than that remarkable optical instrument — the eye — is enormous. And we have concentrated on daytime effects, barely mentioning nighttime observations.

Besides the Moon halos and rainbows, lunar and planetary aureoles and coronae already discussed, there are night sights such as earthlight (a glow near the horizon), the zodiacal light, the gegenschein (literally "counter-glow"), zodiacal band, ashen light (earthshine on the Moon), and luminous night clouds (noctilucent clouds).

And you cannot forget the amazing aurora borealis — the northern lights — the most spectacular sight the heavens can offer. If you've ever seen a third or a half of the entire sky silently pulsating with sheets and drapes of light, you understand. (For a further discussion of the aurora, see "Aurora," ASTRONOMY, October 1975.)

It is surprising how few people even know of any of these light phenomena other than the rainbow and possibly the aurora. Still fewer have seen them. Many people won't believe you if you try to tell them about such sights. I am



Is this a sideways comet or a UFO trail? Actually it is a bright example of a 22° parhelia, or sundog, produced by refraction of ice crystals. Betty Bellinger of Lake Luzerne, New York, exposed Kodachrome 25 for 1/125 second through a 50mm lens at f/5.6.

Near Mt. Whitney, California, at an elevation of 10,000 feet, Lee Peterson photographed this refracted banding effect that acted as a prism and turned the sky into a colorful spectrum. Upper atmospheric ice caused this display which was captured with a 135mm f/2.8 lens set at f/8 and a 1/60-second exposure on Kodachrome 25.

Diffraction caused by water drops sometimes produces colored rings — coronae — around the Sun or Moon. This lunar corona appears red because all the other colors of the spectrum were absorbed by the droplets. Don Dean made this photo with a 35mm lens and a 15-second exposure on Ektachrome 400.

Reflection and refraction of water droplets caused this double rainbow over Edmonton, Alberta. The color sequence in a secondary bow is always opposite that in the primary. Alan Dyer exposed Kodachrome 25 for 1/60 second through a 28mm lens at f/11.

The aurora is familiar to northern observers, and is one of the most beautiful atmospheric displays. Here the constellation Auriga and the Pleiades star cluster are immersed in this celestial glow. Don Carney used a 15-second exposure on Ektachrome 400 and a 35mm lens at f/1.8 to capture this display.

FOR FURTHER READING
on Stormy Days or Cloudy Nights

Greenler, Robert. *Rainbows, Halos and Glories.* New York: Cambridge, 1980.

Humphries, W.J. *Physics of the Air,* 4th edition. New York: McGraw-Hill, originally published in 1920.

Minnaert, Marcel. *The Nature of Light and Colour in the Open Air.* New York: Dover, 1954 (originally published 1937 in The Netherlands).

Schaefer, Vincent and Day, John. *A Field Guide to the Atmosphere* (Peterson Field Guide Series, Number 26). Boston: Houghton Mifflin, 1981.

Tricker, R.A.R. *Ice Crystal Haloes.* Washington, D.C.: Optical Society of America, 1979.

Tricker, R.A.R. *Introduction to Meteorological Optics.* New York: American Elsevier, 1970.

"Journal of the Optical Society of America" (JOSA), August 1979 (special meteorological optics issue).

frequently asked about UFOs. I begin my reply by invariably pointing out that three-fourths of all reported UFO sightings are actually of the planet Venus. Then I continue by mentioning some of the lights described here. Students of atmospheric optics don't report UFOs; they're too busy enjoying the natural sights!

Quite recently I was again asked about UFOs shortly after I had witnessed the finest display of solar ice crystal phenomena I had ever seen, and so, in my naturally enth[illegible] response, I began by trying to describe what I had seen, I quickly became aware that the questioner was becoming bored with my description. Yet I got the distinct feeling that if I had started in on some fanciful tale of UFOs he would have been riveted with interest. Why is it that imaginary UFOs fascinate many people, while spectacular light displays do not? I don't know. It's baffling.

So why not take the day off today — call in *well,* instead of calling in sick — and embark on your own personal journey in a manned space probe (sit in an outdoor chair), turn on your automated television scanners (open your eyes), and engage in observational astronomy (look all around the sky, from the zenith to the horizon and back). Enjoy the continuous light show on the largest screen in the universe. Perhaps your visual sensors will observe twilight colors (Minnaert spends eight pages simply describing such differences in hue and shade during a typical evening). Perhaps they will record a halo, an aureole, some colored clouds (almost always present whenever there are any clouds at all), maybe a mirage, a twinkle, some haze, a glory (easy on wet grass), or who knows what exotic and beauteous sight. If you become adept, you might even see something most physicists consider impossible — direct naked eye evidence of the polarization of sunlight by the Earth's atmosphere (it's known as Haidinger's brushes, best seen 90° from the Sun in a very clear and still sky — I have done so partially by using averted vision, and I'm still practicing on it; and I've had it independently confirmed by a student of mine, and by Minnaert, who, I do believe, has seen everything). The only requirement for any of these and who knows what other marvelous sights or discoveries is for you simply to. . .

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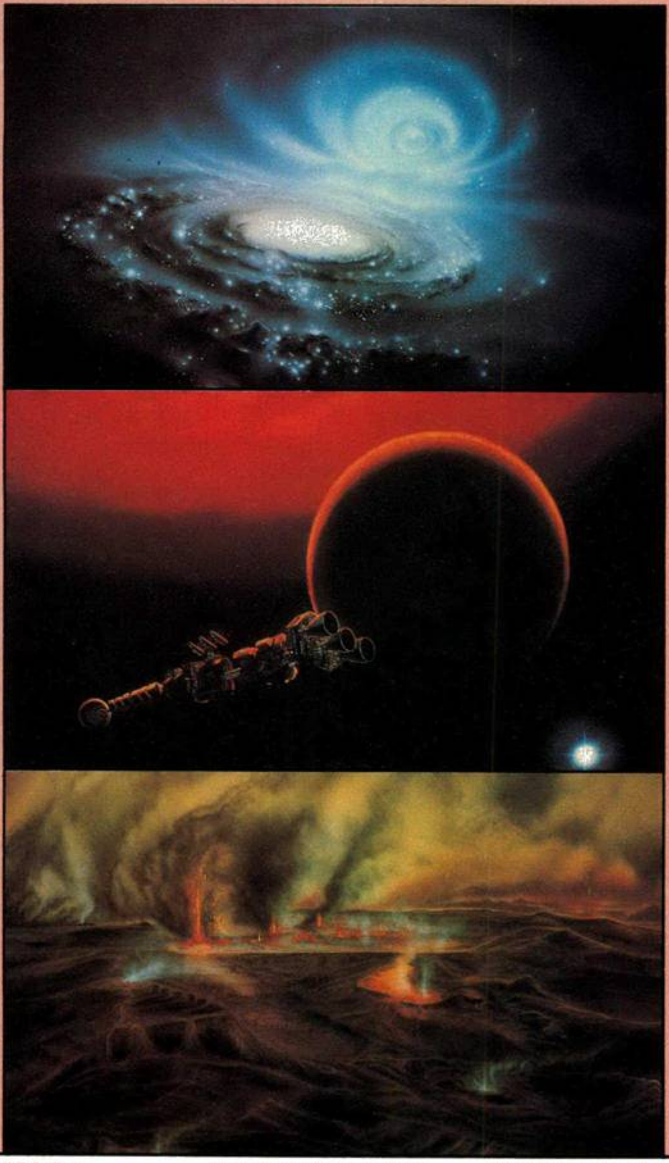

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- ☐AS-04 Triple Star System September 1977, p. 12
- ☐AS-05 Asteroid Belt September 1977, pp. 6 & 7
- ☐AS-06 In The Beginning January 1976, pp. 6 & 7
- ☐AS-07 Vallis Marineris January 1977, pp. 12 & 13
- ☐AS-08 Spiral Galaxy April 1976, p. 19
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- ☐AS-18 Planet in Perseus December 1974, cover
- ☐AS-19 Pioneer 10 Drifting February 1975, p. 28
- ☐AS-20 Unseen Giant of Cygni A April 1976, pp. 6 & 7

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the 2415 revolution

by Jack B. Marling

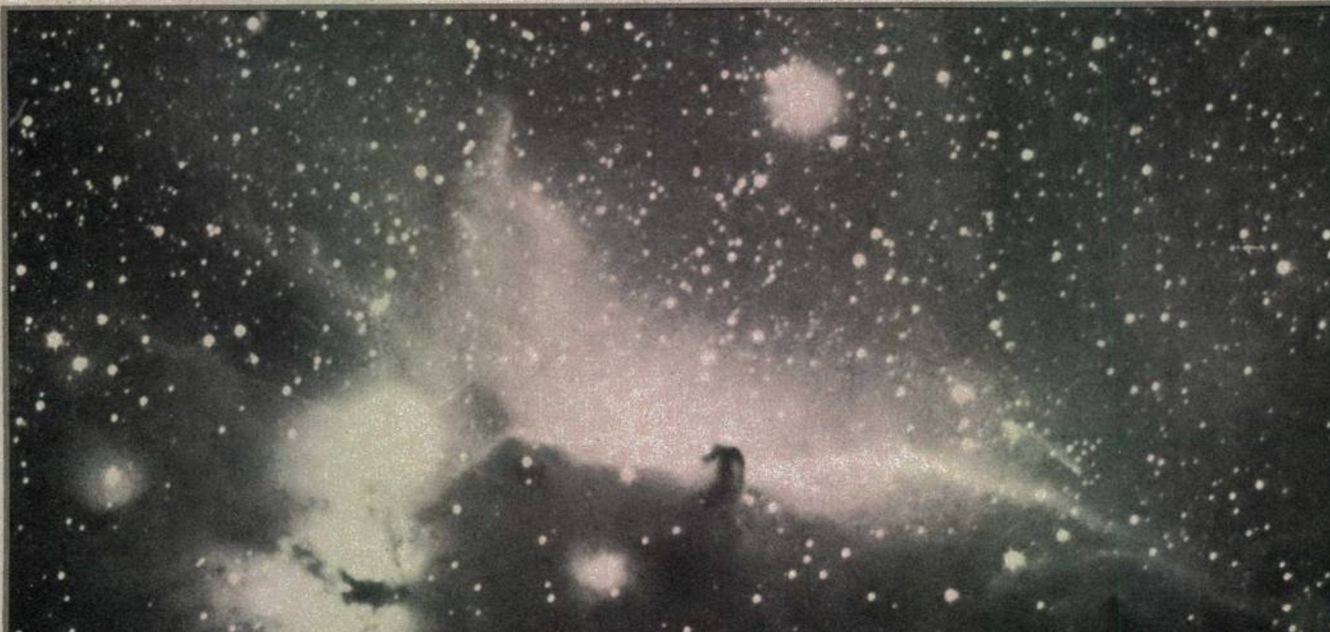
If you're really turned on by taking long-exposure photos of nebulae and galaxies, but have been stymied when using standard films like Tri-X — take heart. A new product that can make your stints in front of your guide scope much shorter and still help you produce photos that rival those taken through much larger scopes has arrived on the scene. And it's just what experienced astrophotographers have been waiting for.

In 1980 Kodak formally introduced a new film for general distribution called Technical Pan Film 2415, formerly a special order film designated SO-115. You can buy it from camera stores in 35mm rolls and 4"x5" sheets. It is an extremely high resolution black-and-white film with high contrast and virtually unnoticeable grain.

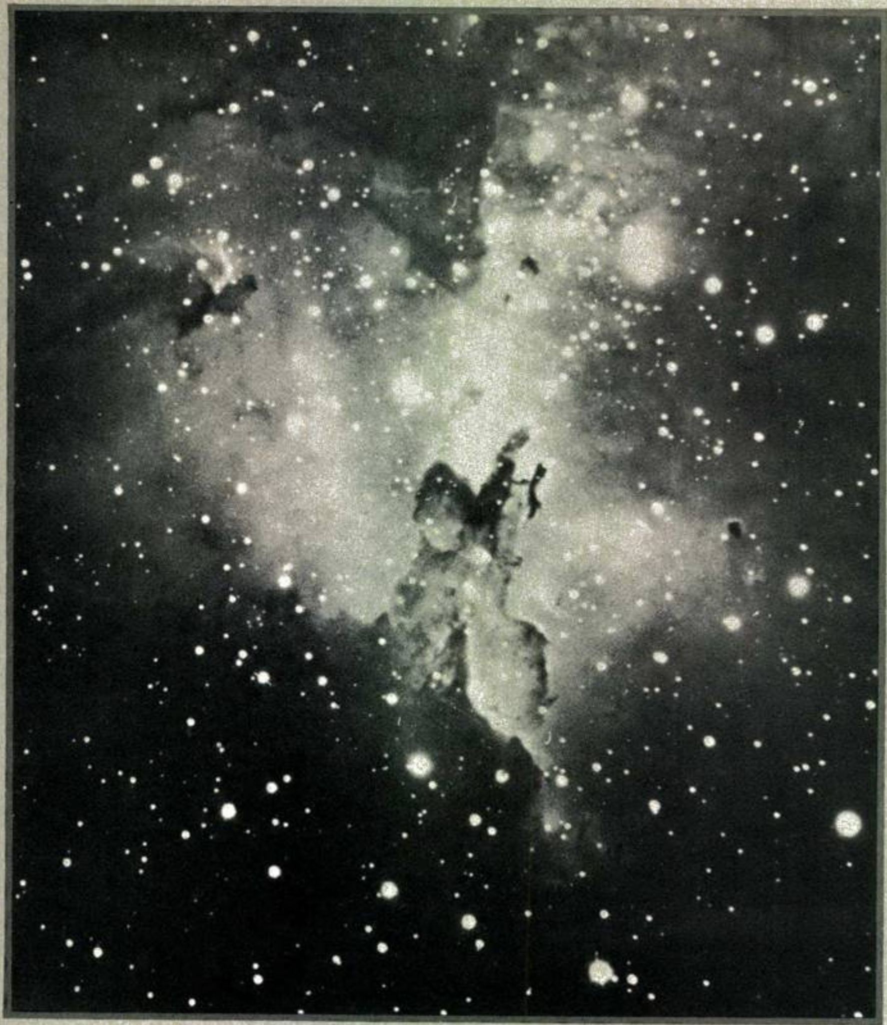
By itself, 2415 would be nothing special. But it can be gas-hypersensitized to yield high speeds in long exposures comparable to the traditional coarse-grained 103a-E or 103a-F spectroscopic films popular with deep-sky photographers for many years. It also has high sensitivity to red hydrogen-alpha light, the type that gaseous nebulae emit, and has excellent panchromatic sensitivity — the ability to record the whole spectrum equally well. And the resolving power of 2415 is 320 line pairs per millimeter — nearly four times better than the 103a emulsions! In short, you now have a remarkable film that will revolutionize backyard astrophotography in the years to come.

Hypersensitized 2415 exceeds many photographers' expectations. It is faster than 103a-E and 103a-F in 60-minute exposures, and might lead you to decide that those films have become obsolete.

The equipment revolution in amateur astronomy (see ASTRONOMY, "Hypersensitizing, Part I," April 1981) means many amateurs own or have access to 12" to 16" telescopes for astrophotography. A system with a 60" focal length (12" f/5) has a seeing-limited resolution that reaches 1 arc-second, corresponding to the smallest image you can record on 2415 film —



Tom Koed took this photo of the Horsehead Nebula from Arkansas. To reduce light pollution, he used a #29 red filter and gas-hypered 2415 in his 8-inch Schmidt camera. Exposure time was 30 minutes, and the film was developed in D-19 for four minutes at 68° F.



The Eagle Nebula, M-16 in Sagittarius, was photographed with hypersensitized 2415 through a 14-inch f/11 Schmidt Cassegrain with a 60-minute exposure. The film was developed in D-19 for four minutes at 21°C. Fine detail and sharp star images show in both light and dark parts of the nebula. Photo by Ron Potter.

nearly a perfect match. For the first time you have a film that can record the smallest object your scope is capable of producing. Indeed it is only 2415 film that can take full advantage of the resolving power of a modest aperture telescope with a 30" to 80" focal length.

Without hypersensitization, 2415 is unsuitable for long-exposure astrophotography. And unlike Tri-X or some color films, 2415 does not benefit from use in a dry-ice cold camera — so gas hypersensitization is the only way to boost 2415's film speed.

There are two methods to gas hypersensitize 35mm film — rolled up in its original cartridge (see ASTRONOMY, "Hypersensitizing, Part II," May 1981) and unrolled on an open reel. For best results, unwind the film and place it on an open reel — if you leave it wound up, it will be less than half as fast. 2415 film takes longer to sensitize than other films in popular use, and you must use high temperatures — up to 60°C — to keep the sensitization time short.

To sensitize 2415 film, follow these steps: First, spool it onto a standard film developing reel (in total darkness, naturally). Then insert it into any suitably heated and vacuum-tight chamber. Next, remove the air with a vacuum pump, and back-fill the chamber with forming gas — any gas mixture containing 2% to 8% dry hydrogen, and a balance of dry nitrogen. (Such mixtures are nonflammable, and are very effective for film hypersensitization.) Now bake the film in the gas for the required number of hours.

Chambers used to sensitize film are simple in principle and only require two valves — one to pump out air and the second to admit forming gas. You also need a gauge to measure vacuum and pressure. Vacuum pumps suitable for sensitizing film range from simple, home-made, hand-operated units to standard laboratory-grade power-driven pumps. If you use a hand-operated pump, flush the chamber out with gas several times before the final fill of forming gas.

Pump out the air, fill the chamber with forming gas, then pump out and fill a second and a third time. Three pump-out-and-fill cycles with a hand-operated vacuum pump will remove 99.9% of the air.

It's better if you can heat the chamber, preferably to 50° to 60° C, while hypering. Sensitization times decrease with increasing temperature or pressure.

At the end of the required "soaking" time, remove the film reel from the chamber—in the dark again—and carefully rewind the film into a 35mm cartridge. You can then insert it into any 35mm camera, and use it like normal film. The speed gain will be 10 times — or more.

If it's too cloudy for astrophotography when the film is finished, don't worry — simply pump out the forming gas, turn off the heater, and leave the film in the chamber. 2415 will store for weeks or months at room temperature without speed loss and can be stored in a freezer for several months with no problems; just seal it up in a plastic snap-top film container. When you get around to using it, it will show little speed loss, even if you left it out for a few days at room temperature.

2415 is considered fully hypersensitized when unexposed frames show a slight darkening after normal development. This darkening is called hypersensitization fog (hyper-fog) and is optimum when the film fog reaches a neutral density of ND = 0.3 (50% transmission or grey in appearance).

Low-contrast developers tend to increase fog, and high-contrast developers yield lowest hypersensitization fog. D-19 seems to be the best developer, since it yields highest speed with lowest fog levels.

Because 2415 is thinner than normal film — 0.004" thick compared to about 0.007" — you'll have to make a small adjustment to insure that it lies flat against your camera's film guide. Place a single layer of cellophane tape against the camera film back — the spring-loaded back-plate in normal 35mm SLR cameras. The tape adds the 0.003" needed to press 2415 flat in the camera. This assures uniform critical focus.

The ultrafine grain of 2415 will show every imperfection — no matter how slight — in focus and guiding, so you may want to use a Barlow lens to increase the guiding ratio. Because even a slight differential flexure can ruin a photo on 2415, use an off-axis guider instead of a separate guide scope. A hand-held 6x finder scope will help you examine the critical focus of any bright field star. If there isn't a bright star in the field, shift to one, check the focus, and then return to your photographic target.

Unfortunately, humidity causes speed loss or increased fogging on

2415. This is not an easy problem to get around. Try cutting 36-exposure rolls of hypersensitized 2415 to smaller 8 to 12 exposure strips, so you only use a small amount of film at a time. Also try advancing one blank frame between photos. Humidity problems are not severe in the west or southwest United States, but could be a problem in the northwest, south, or eastern United States — or other countries where humidity exceeds 70%.

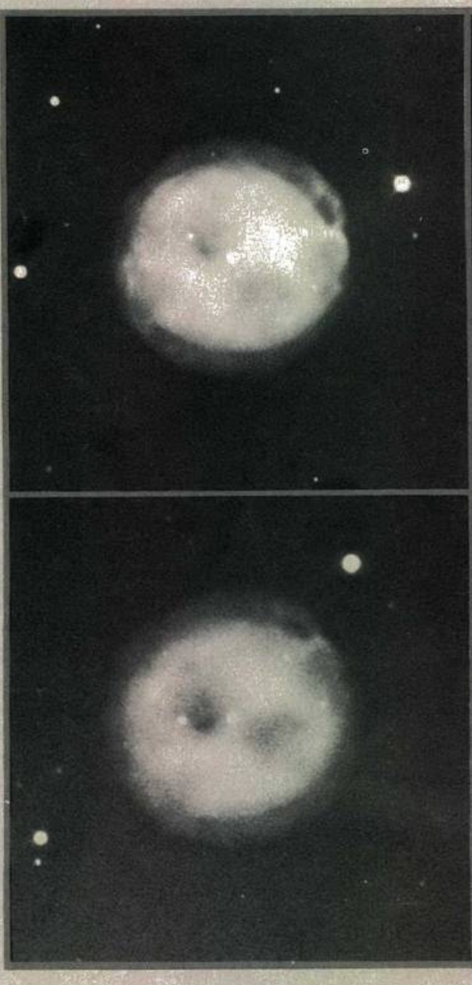
Hypersensitized 2415 has a blue speed about half that of 103a-O or 103a-F, which makes it a bit slow on spiral galaxies. However, it has a superb red speed for hydrogen-alpha light that is at least equal to that of 103a-F. Proper exposure times depend on what kind of celestial object you're photographing, but they also depend critically on the telescope f-ratio. If F = 5 for an f/5 telescope, then a good rule of thumb is to use an exposure of F^2 for most deep-sky targets — say $F^2 = 25$ minutes for an f/5 telescope. Schmidt camera owners should use 5 to 10-minute exposures without filters for galaxies, or 20 to 40-minute exposures with a #92 deep-red Kodak Wratten filter for faint emission nebulae like the Rosette, the North America or the Veil.

In general, faster telescopes — those with smaller f-ratios — give you shorter exposure times. The smaller image scale is not a problem, because you can greatly enlarge 2415 photos.

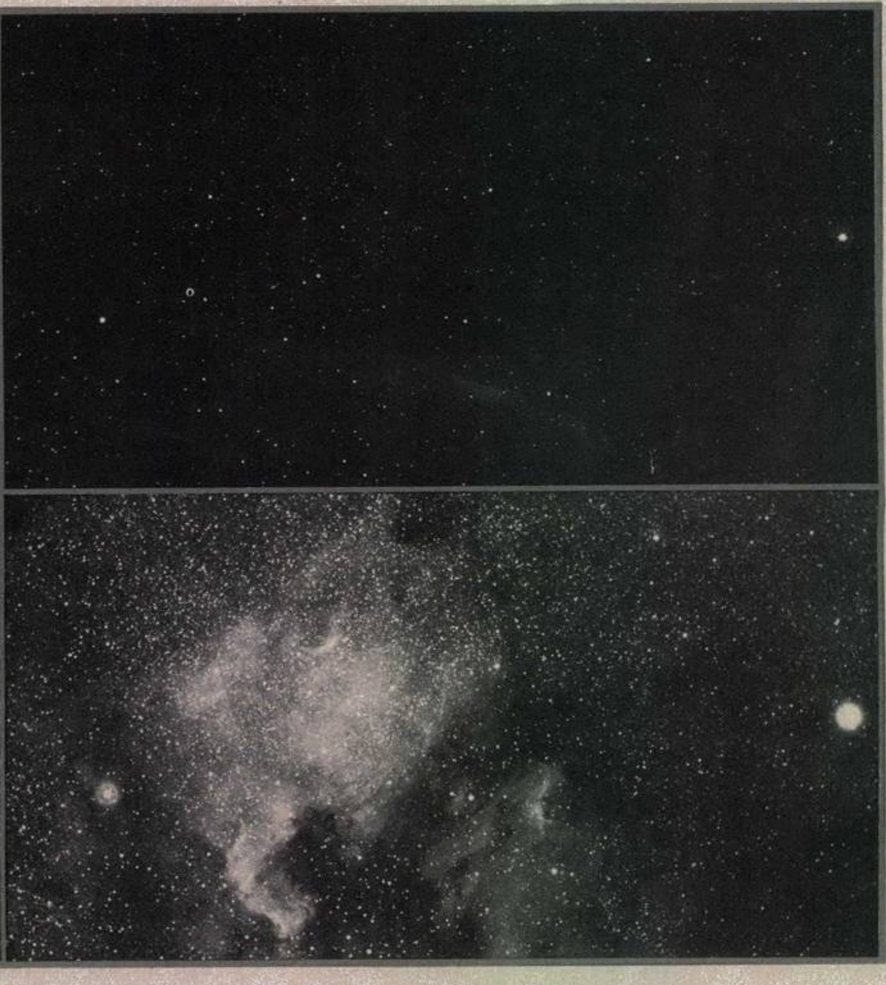
2415 also makes great slides. Since it can have a density range of 100,000 to 1 (ND = 5 to ND = 0), you can produce very black skies with a rich contrast range. Use unhypered 2415 to make slides from your photographs on hypered 2415. Simply insert the 2415 negative into a standard slide copier and rephotograph on normal 2415 using tungsten light and an ASA setting of about 100. Always bracket exposures by ½ to 1 stop. If you use your enlarger, lay the 35mm camera on its back to look up into the enlarger. Use a 90 to 100mm enlarging lens, and lay the negative in upside down (emulsion side up) to give a correct slide orientation. It's easier if you use a right-angle viewfinder on the camera body. Remember to remove the camera lens, but be sure to insert a standard T-mount adaptor ring into the camera body to activate the camera for correct metering. Again, use ASA 100 for tungsten enlargers. Develop all 2415 slides for 4 minutes in Kodak D-19 at 20° to 21° C.

Because of the extended red response of 2415, you can use it with red filters to help reduce visible light pollution. Don't use a filter for spiral galaxies and reflection nebulae, though. For all other deep-sky objects, and especially red emission nebulae, use a dark red #92 Kodak Wratten filter, available from camera stores. Cut it into a circle to fit the filter holder that is available for these specialized telescopes. Do not use the standard red #29 filter, because it does not provide sufficient rejection of light pollution.

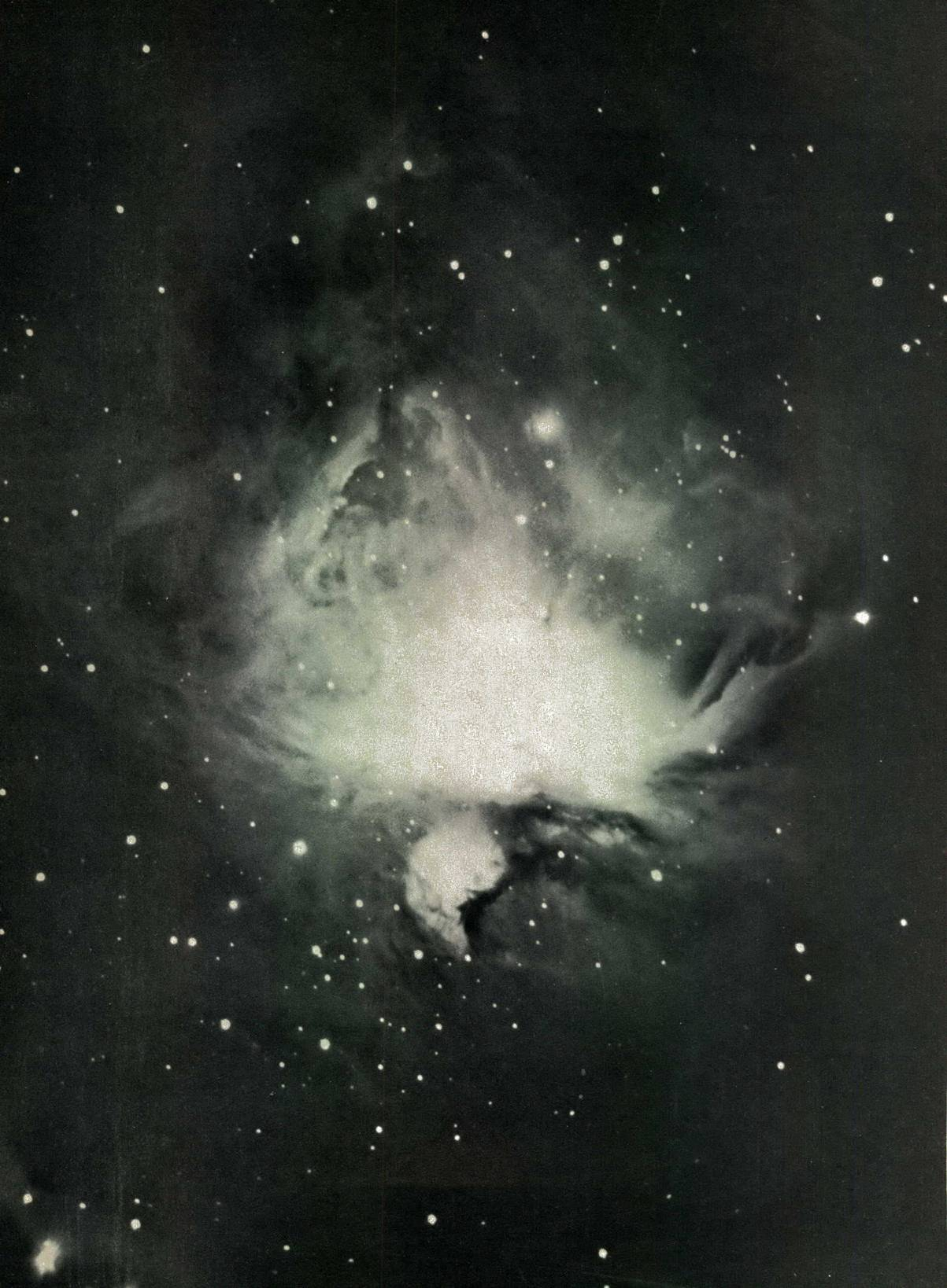
Red filtration also improves the performance of inexpensive telephoto lenses, since it removes chromatic aberration. After refocusing for optimum focus — halfway between the infrared and normal focus on your lens — you'll be able to capture



These photos of M-97 show the gains afforded by using 2415. The top was taken through the Mt. Wilson 60-inch telescope; the bottom is a 4-hour exposure using only a 14-inch f/11 and hypered 2415 through a red filter. Note the similar appearance even though the apertures differ greatly. Photo by Ron Potter.



These are identical 15-minute exposures of NGC-7000, the North America Nebula, in Cygnus, taken through a #92 filter and a 5.5-inch Schmidt camera. The upper photo is on normal 2415, but the film was gas-hypered for the lower. The bright star to the left of the nebula is Xi Cygni, magnitude 3.1. Photos by Patrick Walker.



The Great Orion Nebula, M-42, as photographed by Paul Roques with an 8-inch Schmidt Cassegrain and hypered 2415. He used a 60-minute exposure and a telecompressor lens, and developed the film in D-19 for six minutes at 68°F. The original was enlarged to 11" x 14" and showed very little grain — one of 2415's best characteristics.

pinpoint star images that rival the quality of those made with more expensive Schmidt cameras. Unfortunately, the standard red threaded filters for telephotos (#25 filter) do not reduce light pollution very much. Many communities now are switching to high pressure sodium streetlamps which create red light pollution that passes right through a #25 filter.

If light pollution is severe, a specialized shortpass filter can help. This type of filter blocks natural airglow and green/orange light pollution, but transmits blue and ultraviolet light.

For emission nebulae photography from cities, a medium red filter, such as a #25 or #29 glass filter, makes it easier to see the target through the camera. You can also use a nebula filter. Be sure that yours is a "photo visual" filter, one that has high transmission for hydrogen-alpha light — 60% to 90% transmission at 656 to 658nm. Some "visual" nebula filters have only 0% to 30% transmission at hydrogen-alpha, and are not suitable for astrophotography.

It certainly sounds like 2415 will open up a new era of high resolution backyard astrophography. You can use it with fast, short focus instruments, like Schmidt cameras, telephoto lenses, and fast Newtonian telescopes, and also with popular f/10 Schmidt-Cassegrain telescopes — providing you use a long exposure or a telecompressor lens. You can easily hyper 2415 by "soaking" it in forming gas unwound on an open reel for one to two days at 50° to 60°C. Its speed after hypersensitization compares with the coarse-grained 103a spectroscopic films. A properly focused and guided photo on 2415 will rival the quality of photos made with older type films through telescopes of much larger aperture.

For More Information

Eastman Kodak Co., Department 757, Rochester, NY 14650. Request Publication P-255 on 2415 film.

Edgar Everhart, "Adventures in Fine-Grain Astrophotography" *Sky & Telescope*, February 1981.

Roger Sliva, "Hypersensitizing," ASTRONOMY, April and May 1981.

2415 data

sensitization time in forming gas

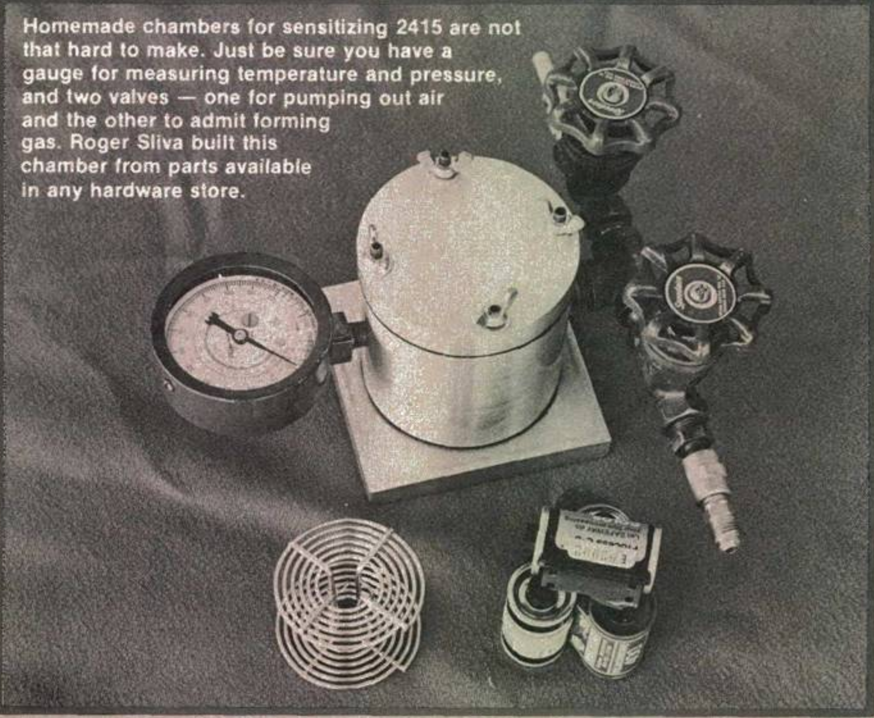
Temperature	Pressure	Soaking Time
40° C	15 psi	100-125 hours
50° C	1 psi	40-50 hours
50° C	15 psi	24-36 hours
60° C	1 psi	16-20 hours

developer performance

Developer	Conditions	Relative Speed	Hyper-Fog
Kodak D-19	4 min. 69° F	10	ND = 0.15
Kodak D-19	7 min. 70° F	15	0.40
Acufine	4½ min. 69° F	11	0.40
H & W Control	5½ min. 68° F	5-6	0.30

exposure time after hypering

Target	f/5	f/7	f/10
Planetary Nebulae	3-15 minutes	5-25 minutes	10-50 minutes
Emission Nebulae	10-30 minutes	20-45 minutes	40-90 minutes
Globular Clusters	10 minutes	15 minutes	20 minutes
Spiral Galaxies	25-50 minutes	45-90 minutes	90-180 minutes
Elliptical Galaxies	10-30 minutes	20-45 minutes	30-90 minutes
Moon and Planets	Use ASA = 250 film speed		



Homemade chambers for sensitizing 2415 are not that hard to make. Just be sure you have a gauge for measuring temperature and pressure, and two valves — one for pumping out air and the other to admit forming gas. Roger Sliva built this chamber from parts available in any hardware store.

POSTER GALLERY

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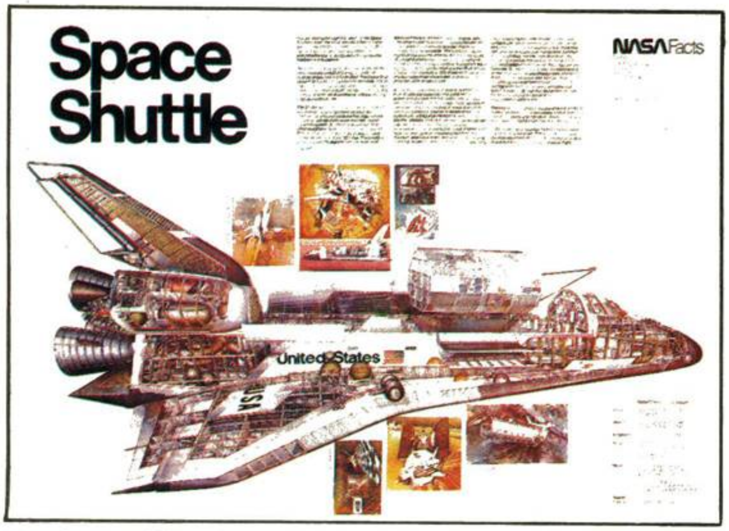
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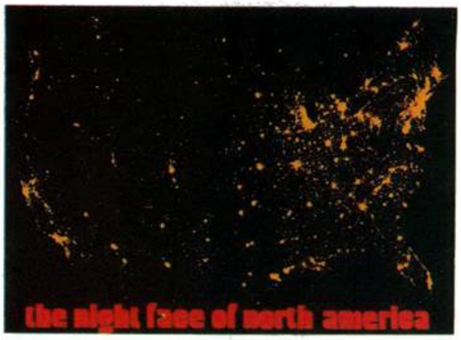
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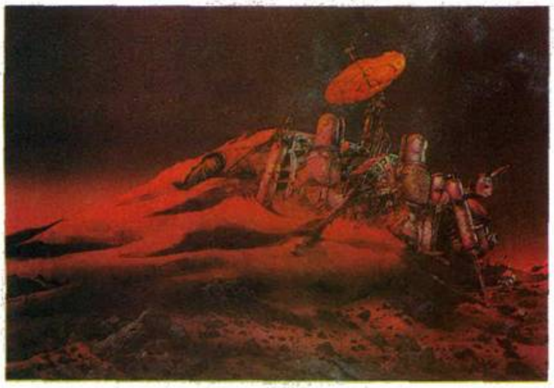

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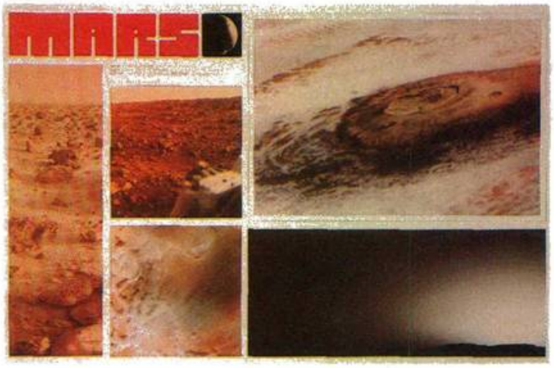

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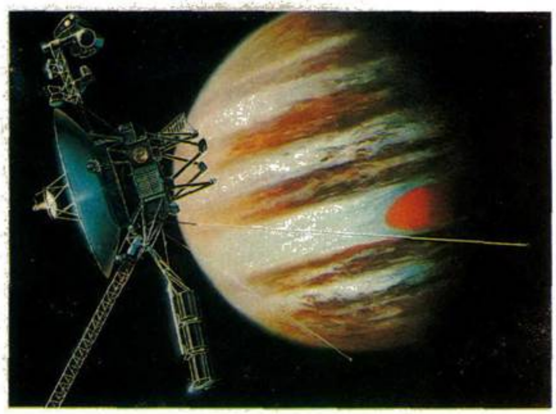

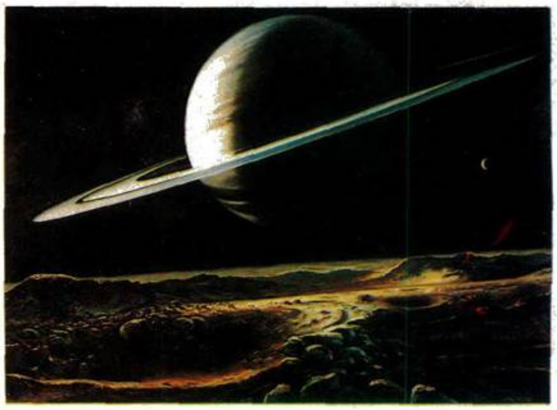

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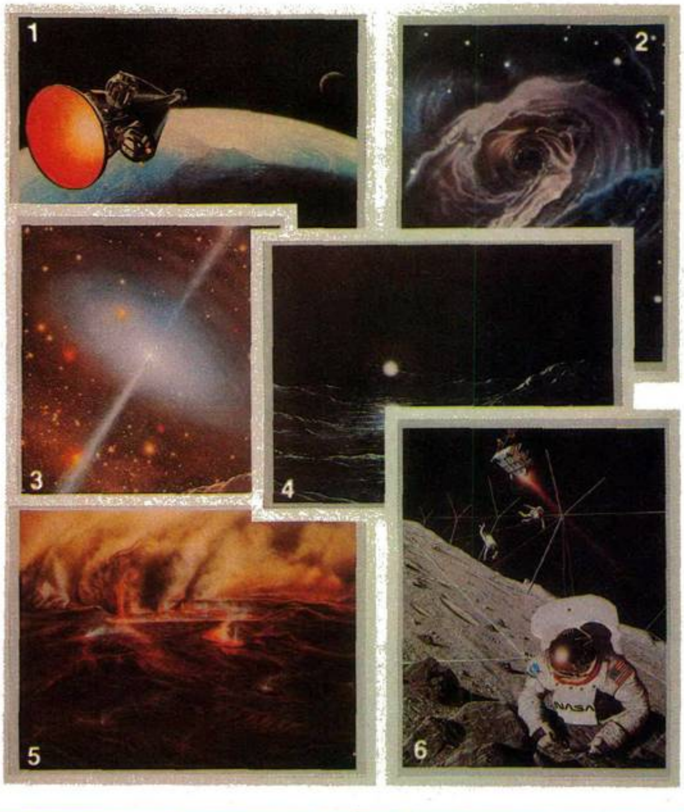


AstroNews

Asteroid Mission Receives Serious Thought

Asteroids have long been considered the leading potential sources of the materials necessary to settle and industrialize space. In addition to nickel, iron, and other minerals useful for construction, they may contain free or bound water.

Recognizing the significant return to both scientists and future inhabitants of space, the Jet Propulsion Laboratory and Science Applications, Inc. have been planning missions to asteroids. Two classes of missions have been considered: rendezvous and sample return.

Rendezvous requires sending a spacecraft on a transfer orbit, then applying an impulse to move the craft at the same speed and in the same direction of the targeted body. The spacecraft can then, with a small additional impulse, orbit the asteroid. Scientific instruments will remotely measure the characteristics of the body and transmit their data back to Earth.

A sample return mission calls for a rendezvous and a landing followed by sample recovery and return to Earth. Scientific instruments would be included to collect data on-site.

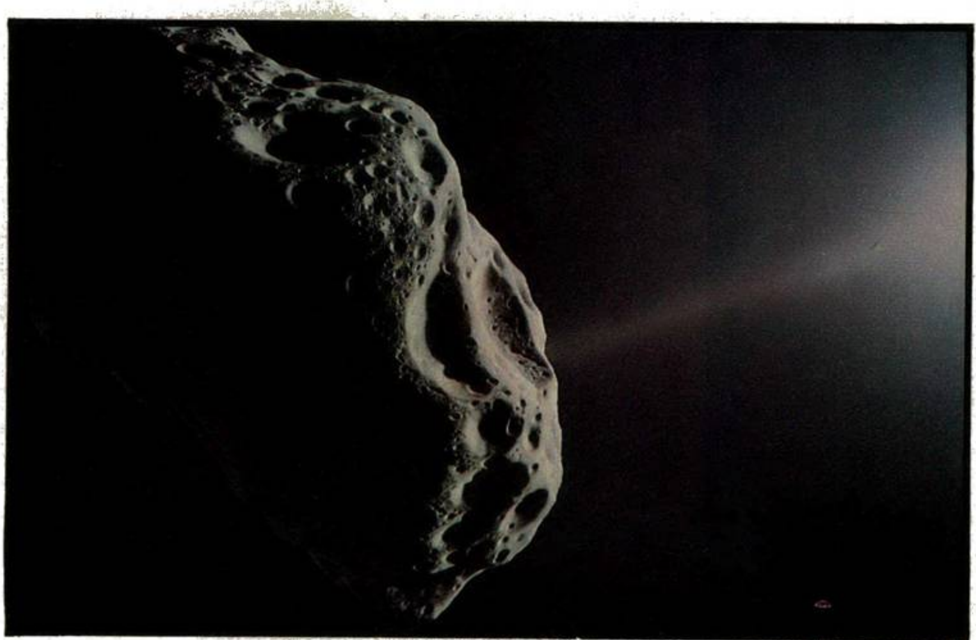
Today's interplanetary spacecraft are sent on ballistic trajectories; an initial impulse propels them from Earth's orbit toward the target with only an occasional small burn to correct the course. A second large impulse is given to the spacecraft on arrival enabling it to rendezvous or orbit.

More than 100 opportunities to rendezvous ballistically with near-Earth asteroids have been identified for this century. The most accessible candidate for such a rendezvous is the asteroid Anteros which offers opportunities every two years. Launchings to this asteroid in 1985, 1987, and 1990 have received serious study and the large inner main belt asteroid Vesta may be targeted for 1986.

A multiple asteroid flyby mission using a very simple scientific payload launched by an Ariane rocket has been proposed by a group of European scientists. But this type of mission cannot be accomplished ballistically and still fulfill the objectives set by the Committee on Planetary and Lunar Exploration (COMPLEX), a major scientific advisory board to NASA. Instead, it would require a low-thrust propulsion system, such as NASA's Solar Electric Propulsion System (SEPS), or solar sails.

The maiden voyage of SEPS and the second solar sail mission may be a multiple asteroid rendezvous with Anteros targeted as the first body to be visited. Three to seven additional objects, probably main belt asteroids, would then be examined in succession. After the study, the spacecraft would remain in the vincinity of each target for up to two months gathering scientific data remotely and perhaps performing on-site measurements with a landed package.

The practical experience gained in maneuvering about a small asymmetric body would be beneficial to future asteroid miners and planners of touchdown missions. And a determination of the types and abundances of materials composing the asteroids would be the first step in converting these shards of creation into the building blocks of the future. In addition to this, a visit to an asteroid would offer planetary scientists profound insights into the birth of our solar system.
— © *E. Helin/N. Hulkower.*



Painting by Adolf Schaller

Two Soviet Probes to Land on Venus This Month

The Soviet Venera 13 and 14 probes due to land on Venus in March 1982 will be the first to have their landing sites selected using the new U.S. radar maps. They will also be the first craft on Venus to bring soil samples inside themselves for detailed chemical analyses. American scientists believe the data returned by the probes will test current interpretations of Venus' geology.

Geologists have used the radar mapper unit aboard the U.S. Pioneer Venus orbiter to prepare the first global map of the cloud-enshrouded second planet. Although the resolution is poor — topographic *details* are more than 20 kilometers across — geologists have begun comparing Venus' geology with that of other worlds. "Our understanding of Venus is based on subjective reasoning," said Harold Masursky of the U.S. Geologic Survey and chairman of the Pioneer Venus Mission Operations Group. "If a venusian region resembles a martian or lunar region, we can hypothesize that their geology is similar. To be really convincing, though, we must back our arguments with the kind of objective data the Venera probes can provide. If the soil or rock composition at their landing sites match what our hypotheses predict, we're on surer ground."

Soviet scientists, with Masursky's assistance, used the radar maps to target the probes so they will study the two most widespread terrain types. One probe will land just east of the possibly volcanic area Beta Regio where the Soviets hope to study the rolling plains, a terrain that covers 65% of the planet and resembles the ancient lunar and martian highlands. The second probe will land to the southeast where the Soviets hope to study the lowlands that cover 27% of the planet. This area could resemble lowlands on the Earth, Moon, and Mars.

The two craft will have the same basic design as the last four Venera landers, one of which operated for nearly two hours in the 455°C temperature and 90 Earth-atmosphere pressure of the venusian surface. As did their predecessors, Veneras 13 and 14 probably will study the structure and composition of the atmosphere during their descent.

Once on the ground, each probe will photograph its surroundings with an imaging system said to be better than those carried by the Veneras 9 and 10 probes that provided the only pictures to date from the surface. Veneras 11 and 12 either didn't carry cameras or the cameras they did carry failed to operate.

Each probe will use a screw-type mechanism to draw a minute sample of rock or soil inside itself for a detailed chemical analysis using X-ray fluorescence. Previous landers used a less refined method — gamma-ray spectroscopy — to measure the radioactivity of the surface material outside themselves. Masursky believes the first probe should find granite-like material if it lands on the rolling plains and basaltic material if it lands on the volcanic region. The probe landing in the lowlands should find basalts.

The results of past Soviet landers support Masursky's view of Venus. Venera 8, the first, put down on the rolling plains in 1972 and found soil roughly similar to that in the lunar highlands. In 1975, Veneras 9 and 10 fell onto the flanks of the volcanic Beta Regio and found the expected basalts. The gamma-ray spectrometers on Veneras 11 and 12 in 1978 failed to operate.

Geologists will get another chance to test their theories in 1985 with the landings of Veneras 15 and 16 in the eastern Aphrodite region where topography suggests recent geologic activity. The surface studies will be similar to those of Veneras 13 and 14 except that the probes may not carry cameras because the landing sites are on the night side.

The earliest the United States could return to the veiled planet will be 1988 when NASA hopes to launch its Venus Orbiting Imaging Radar (VOIR) mission. The VOIR spacecraft will map the surface with a resolution at least a hundred times better than Pioneer Venus' resolution and will allow geologists to relate the data from each Venera landing site to individual geologic features instead of broad, poorly imaged terrain types. *Van Kane.*

Franco-Soviet Team Plans Venus/Halley Mission

A planned Soviet-French balloon probe of Venus has evolved into an ambitious investigation of both Venus and Halley's Comet.

The good and bad news was delivered by Jean-Loup Bertaux, Deputy Director of France's National Center for Space Research, during the NASA-sponsored International Conference on the Venus Environment held recently in Palo Alto, California. According to Bertaux, "the French side is a little bit angry about having lost the balloon mission, but on the other hand, a whole community of scientists is now going to study Comet Halley with great enthusiasm, so I think we are very delighted to have this comet mission."

Preparations for the two-country Venus mission have been underway for several years. The French had already tested a prototype of the 9-meter balloons that would have floated at a fixed altitude in Venus' clouds for several days and returned data to an orbiter for transmission to Earth. But a couple of years ago, Bertaux notes ironically, "suddenly someone in the U.S.S.R. came up with the bright idea that Comet Halley was coming. Of course, on this side of the Atlantic, everyone already knew that." Soviet scientists wanted to do a two-craft Halley mission in addition to the two-craft Venus probe, but financial considerations forced them to lower their goals.

Two identical Vega spacecraft will be launched in December 1984 or January 1985. One part of each vehicle will be a standard Soviet Venera-type probe which will land on Venus; the other will sweep past the planet on a Halley-intercept trajectory. The first Vega will fly by the comet on March 8, 1986, with the second arriving some days later.

At Venus, the probe will study the composition of the planet's clouds, atmosphere, and surface. Soviet scientists are consulting with their U.S. counterparts to determine landing sites that will give the most valuable data. There is even the possibility of including some very small balloons on Vega that would drift around Venus at different altitudes, allowing study of cloud circulation patterns. But these would carry equipment much less sophisticated than that originally planned for the 9-meter balloons.

Each Halley encounter probe will be three-axis stabilized with a scan platform which will allow flexibility in pointing. This is necessary because scientists are uncertain of the comet's exact orbit. The stabilization will also produce sharper photographs than those made by instruments on the European Space Agency's spin-stabilized Giotto craft.

Vega will approach within 10,000 kilometers of Comet Halley's nucleus. This will not be as close a flyby as that made by Giotto, but as Bertaux explains, "the Giotto mission wants to approach as near as possible — even perhaps with a 'kamikaze' trajectory — because mission scientists want to make *in situ* measurements. The Vega mission is different; we want the spacecraft to survive and make photographs from every side of the nucleus."

When the Vega team observes Halley's nucleus, they expect a narrow-angle camera resolution of about 200 meters. A wide-angle camera wil correlate irregularities in the comet's tail — reportedly seen to extend 100,000 km from the nucleus at the 1910 apparition — with visibly differing parts of the nucleus. An ultraviolet/visible/very near infrared spectrometer will look for clues to the nucleus's composition in gas emissions. A French-made far-infrared instrument will search for water vapor and CO_2 emissions, and determine the size of the nucleus if too much dust obscures the camera's view.

Other Vega instruments include a mass spectrometer to analyze the comet's dust, a particle counter, and plasma and magnetism detectors.

Patty Winter.

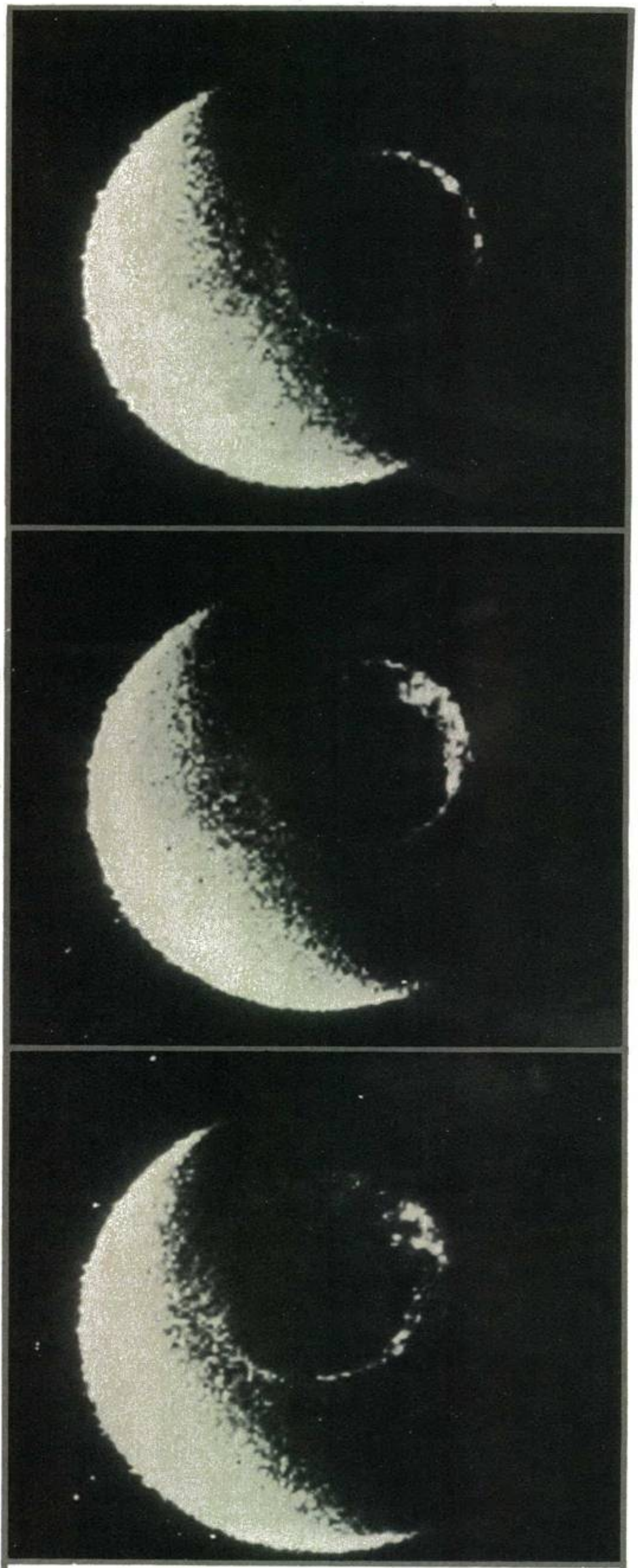
NASA's Dynamics Explorer Photographs Auroral Storm

One of two NASA Dynamics Explorer satellites has made the first photograph of an entire auroral oval and captured a sequence of images showing the development and decay of an auroral storm.

Lou A. Frank of the University of Iowa explained that the photos were made possible by cameras which allow the auroral lights to be "seen" over the intense light from the sunlit Earth that usually floods out an aurora.

In addition to the spectacular auroral pictures, scientists are acquiring data which will lead to a better understanding of the powerful mechanism which shoots beams of electrons into the Earth's atmosphere and creates the aurora while generating radio waves 3000 times more powerful than signals from commercial radio stations. The sounds of this auroral activity are similar to hisses and whistles we hear on Earth.

The Dynamics Explorer satellites were launched on August 3, 1981 to explore the space around Earth from the limits of the upper atmosphere to distances far out in the Earth's magnetic field. The satellites work in harmony, one operating at a high altitude and one at a lower altitude. They acquire data simultaneously, one in the magnetosphere and the other in the ionosphere.



This sequence of three images made by NASA's Dynamics Explorer satellite shows the first evidence of an auroral storm photographed from space. The circular image in the middle of the picture is the storm; 24-minute intervals separate each image. From left to right the photos depict a quiet period, the peak of the storm, and then the recovery. NASA photo.

3-10-46

Giant Telescope Nears Completion; May Bare New Atomic Secrets

Mt. Palomar, Calif.—(INS)—This is the dateline of tomorrow.

It is here that astronomers, peering down into the 200-inch mirror of the largest telescope ever built, will range the universe of stars beyond the imagination of the earthbound.

Elusive atomic secrets of the universe may soon be cracked by man's latest wonder worker.

Now nearing completion, after 18 years' concentration of scientific and engineering skills, the giant of Palomar will photgraph heavenly bodies so far away that their light takes a billion years to reach us.

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So powerful is this optical giant that it would make New York's Empire State Building clearly visible to an observer on the moon.

In fact, the glass giant, in effect, brings moon and earth to within 25 miles of each other. The moon's distance from the earth averages nearly 239,000 miles.

With the telescope, the faint stars of our own Milky Way will become bright, and the bright stars, such as Sirius, may yield a spectrum almost as bright as the one we now get from the sun.

Astronomers, alert tothe implications of the atomic age, are anxious to turn the instrument on the exploding stars—atomic explosions of such magnitude that, in comparison, Hiroshima and Magasaki were as firecrackers.

When the new $6,000,000 reflector begins working in 1947, astrophysicists hope to unravel some of these other persistent problems:

Is the universe expanding, as many believe? Or is it old and static, in danger of running down like a spent watch spring?

Editor's note: We found this newspaper clipping, dated 3/10/46, in our library copy of The Glass Giant of Palomar *written by David Woodbury and published by Dodd Mead & Company in 1940.*

The paper is yellowed, but the enthusiasm of the writer still shows through in his description of the capabilities of what was soon to be the most powerful telescope in the world — the Hale 200-inch.

The Hale scope's tremendous light-gathering power has taken astronomers closer to the edge of the universe than any other telescope, and has been used to study quasars and pulsars — exotic astrophysical objects not even dreamed of when the article was written.

Cataclysmic Variable Stars Identified through X-Rays

Cataclysmic variable stars like U Geminorum and SS Cygni are binary star systems that consist of a large red star and a white dwarf. At irregular intervals, the white dwarf pulls material from the extended outer atmosphere of the red star. Impelled by the strong gravitational field, the material falls onto the surface of the white dwarf with great speed and emits a sudden flash of radiation.

The greatest number of these variable stars have been discovered through observations of changes in their light at optical wavelengths — and some are also found to be variable in X-rays. But recently, the opposite process has occurred: some new cataclysmic variables have been discovered because astronomers noticed their X-ray emission first. The latest such case is the X-ray source 4U 1849-31 which a team of astronomers has just linked to the 13th magnitude variable star, V1223 Sagittarii.

Previously cataloged as an irregular variable, V1223 Sgr seems instead to be a cataclysmic variable, as the discoverers report in a recent issue of *Astrophysical Journal Letters*. Evidence for this comes from observations of color, magnitude, and spectrum — all of which are typical of cataclysmic variables. The astronomers also observed a 13.2-minute period of variability which they think is a result of the axial rotation of the white dwarf.

J.E. Steiner and D.A. Schwartz of the Harvard-Smithsonian Center for Astrophysics, F.J. Jablonski and I.C. Busko of Observatorio Nacional, Brazil, and M.G. Watson, J.P. Pye, and I.M. McHardy of the University of Leicester made the discovery. *Ken Croswell.*

Search for Halley's Comet Stepped up at Kitt Peak

Believing that Halley's Comet can now be picked up by our largest telescopes, Kitt Peak astronomer Michael Belton is stepping up his five-year effort to rediscover the famous comet. Halley has not been seen since its last passage near Earth and the Sun in 1910.

The comet is expected to return to Earth's vicinity in late 1985. It is currently beyond Saturn's orbit at about 1.2 billion miles out from the Sun — considerably more distant than any comet previously observed. Still, with the aid of modern electronic detectors attached to large telescopes, Belton hopes he can soon find the comet in its dormant state, well before it approaches close enough to the Sun to form its tail of gases and dust.

On the night of December 2, 1981, he searched for the comet using Kitt Peak's 4-meter Mayall telescope connected to a video image intensifier. Although the comet was expected to be brighter than the 24.3 magnitude limit of the instrument, data reductions have failed in acquiring it. But Halley is getting brighter so Belton will continue his search.

The astronomer is pessimistic about the future. "With the advances and development of the space program since the comet's last apparition in 1910, you would expect the United States to be leading the way to close up exploration of this comet with a spacecraft. Comets are of fundamental scientific importance in their ability to provide us with clues on the formation of our solar system and its chemical nature before life arose on Earth.

"With our exciting and successful missions of the past — Vikings, Mariners, Pioneers, and Voyagers — we're the best in the business. Yet a number of the major nations capable of spaceflight are launching space probes to Halley's Comet — but not us. We can still mount a credible mission, but time is running out."

AstroCalendar

March 7-11.	**American Institute of Aeronautics and Astronautics (AIAA)** Ninth Annual Communications Satellite Systems Conference (professional meeting). Town and Country Hotel, San Diego, CA.
March 15-19.	**Thirteenth Lunar and Planetary Science Conference** (professional meeting). NASA's Johnson Space Center, Houston, Texas. Contact: 13th LPSC, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058.
March 22.	**STS-3 Launch.** Kennedy Space Center, Cape Canaveral, Florida.
April 28-30.	**19th Space Congress "Making Space Work for Mankind."** Cocoa Beach Florida. Contact: Melodie de Guibert, P.O. Box 1333, Cocoa Beach, FL 32931.
May 1.	**Telescope User's Clinic.** Contact: Western Observatorium, 13215 E. Penn St., Suite 411, Whittier, CA 90602.
May 18-22.	**Saturn Conference** (professional meeting). Tucson, Arizona. Contact: M.S. Shapley, University of Arizona, Lunar and Planetary Laboratory, Tucson, AZ 85721.
May 26-30.	**Amateur Astronomy and Telescope Making Conference** sponsored by the Astronomical League's S.W. Region. Fort Davis, Texas. Contact: George D. Ellis, 7117 Misty Meadows Dr. S., Fort Worth, TX 76133.
May 28-31.	**Riverside Telescope Maker's conference.** Big Bear Lake, California. Contact: Cliff Holmes, 8642 Wells Avenue, Riverside, CA 92505.
June 11-12.	**12th Annual Apollo Rendezvous and Telescope Fair.** Contact: Coordinators, APOLLO RENDEZVOUS, 2629 Ridge Avenue, Dayton, OH 45414.
July 18-August 8.	**International Workshop for Amateur Astronomers** (I.W.A.A.). Havelte, The Netherlands. Contact: Niels van Weersen, Sand-Ambachstraat 17, 2691 BL 's Gravenzande, The Netherlands.
July 21.	**24th Annual Summer Science Program in Astronomy.** Ojai, California. Contact: Roger D. Klauscer, Thacher School, Ojai, CA 93023.
July 21-24.	**ALCON '82** — national convention of the Astronomical League including ALPO, IAPPP, IOTA and National Deep Sky Observers annual meetings. Peoria, Illinois. Contact: ALCON '82, P.O. Box 5203, Peoria, IL 61601.
August 14-17.	**Stellafane.** Breezy Hill, Vermont. Contact: Dennis di Cicco, 60 Victoria Road, Sudbury, MA 01776.

Send information on meetings to:
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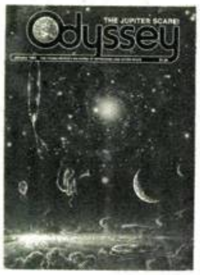

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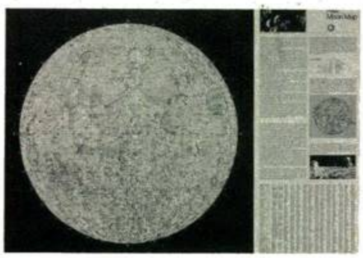

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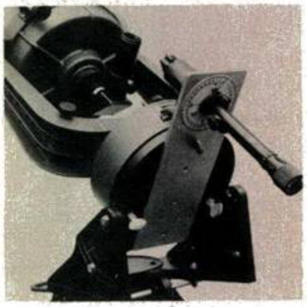

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Though it weighs in at a little more than 100 pounds, this 840X instrument quickly breaks down into components weighing no more than 50 pounds each, making transport to a dark sky observing site easier than it is with many smaller, conventionally mounted classical telescopes. In fact, when used terrestrially the C14 tube assembly becomes the world's largest mirror/lens telephoto, with an effective focal length of 3,900mm at f/11.

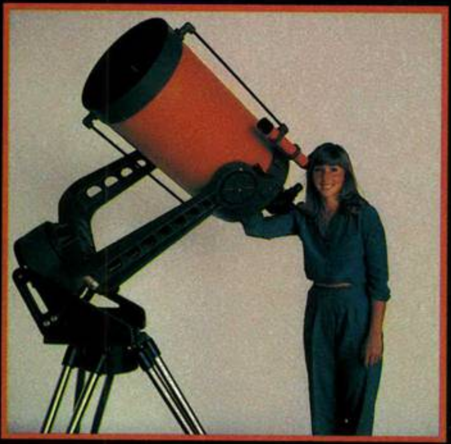
As an astronomical telescope, the Celestron 14, with 2,314 times the light-gathering power of the human eye, is a superior instrument indeed — whether for lunar, planetary, or deep sky observations. And the prestige of the instrument is enhanced by such amenities as a control panel and electrical slow motions in both axes.

Through the Celestron 14, when the air is steady, the cloud belts of Jupiter are delicately festooned and display an enormous range of colors from cream through orange to grey, and within the belts are numerous smaller storms (white spots). Detail can even be glimpsed within the Red Spot and on the largest Jovian moon Ganymede (but only when seeing conditions are most favorable).

With the C14, the major divisions of Saturn's ring system are instantly obvious, and the observer's attention is drawn to the surface detail of the planet itself. There is a striking amount of banded detail on the globe, usually including one or more white spots, and there is a hint of belt structure near the polar region. The observer will notice, too, that Saturn's moon Titan appears as a disk.

In fact, at this aperture the domain of the observer encompasses virtually the entire solar system from tiny lunar rills broken by even tinier craterlets, through the bluish-green disks of Uranus and Neptune, to the pinpoint image of Pluto moving from month to month across faint star fields. But the solar system is only a small part of the observer's domain, for at this aperture, globular clusters are so well resolved that each seems to have its own personality. Galaxies are revealed in intricate detail, and even the brighter quasars may be reached.

Well within visual reach of the C14 are such open clusters as M35 or M11, such globular clusters as M13 or M3, such emission nebulae as the Orion Nebula or the Trifid Nebula, such planetary nebulae as the Dumbbell Nebula or the Ring Nebula, and such galaxies as the Whirlpool Galaxy or the peculiar galaxy M82.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Through the C14,

- the tiny companion cluster of open cluster M35 is resolved,
- open cluster M11 is revealed as a spectacular, densely packed, strikingly noticeable gathering of hundreds of stars,
- numerous dark lanes and streamers of stars radiate outward from the cores of globular clusters M13 and M3,
- the intricate filamentary network of the Orion Nebula is laced with many knotty brightenings, and the dark clouds of the nebula are crisply defined,
- both components of the Trifid Nebula are well detailed, with the brighter clearly trisected by dark lanes,
- The Dumbbell Nebula becomes a complete oval with scores of stars apparently embedded in its gossamer beauty,
- the contrast levels of the Ring Nebula are evident, and its central star may be glimpsed occasionally,
- galaxy M82 resembles a curved needle, with many knotty brightenings toward its center.

And that's just the beginning. Countless other celestial wonders await the owner of this telescope.

For photography, convenient adaptors — some of which are included in the base price with this instrument — attach your 35mm SLR camera body or body-plus-lens to the Celestron 14, permitting telephotography, wide-field lunar photography, close-up lunar and planetary photography, basic deep sky photography and constellation photography.

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Arc seconds (Dawes' limit)	0.3
Stellar magnitude limit	15
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Secondary obstruction	10% (4½ in. dia.)
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Polar axis diameter	1⅜ in. tapered
Setting circles	Dec. 6 in., R.A. 9¼ in.
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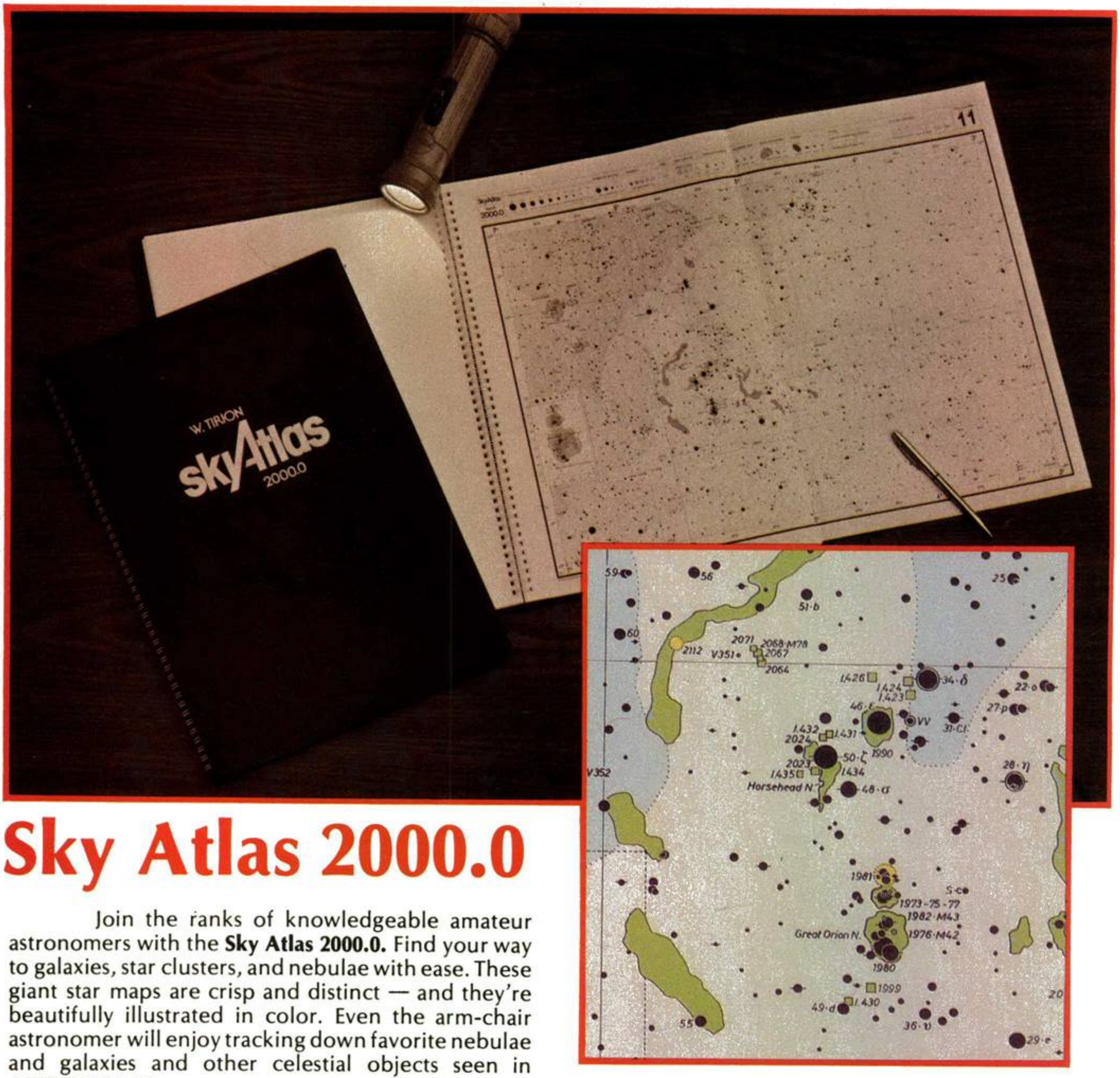
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ASTRONOMY REVIEWS

A Complete Manual of Amateur Astronomy

P. Clay Sherrod with Thomas L. Koed
319 pages, paperback, $10.95
Prentice-Hall (1981)

Subtitled "Tools and Techniques for Astronomical Observations," this volume reads like a condensed and updated version of J. B. Sidgwick's classic works, *Observational Astronomy for Amateurs* and *Amateur Astronomer's Handbook*, published in the 1950s. Like those two books, it will appeal primarily to telescope owners who want to observe in a systematic manner. Casual stargazers can also learn a lot from it, but they are not the principal readers the authors have in mind.

The book is jam-packed with practical observing information and techniques. Topics covered in 14 chapters and 15 appendices include instruments and techniques, the Sun, Moon, Mars, Jupiter, Saturn, minor planets, comets, meteors, variable stars, and astrophotography. These subjects are written about from the perspective of people who have spent many years at the telescope. As a whole, the coverage is well-informed and well-thought out.

But there are a number of significant omissions that need pointing out — after all, any book that claims to be a complete guide ought to deliver. For example, the role of amateur observers in patrolling the Moon for transient lunar phenomena (TLPs in the jargon) is not mentioned. Likewise, watching for flares or flashes of light on the surface of Mars is not discussed. Patrols of both the Moon and Mars have added to our knowledge of the solar system on many occasions over the years.

Another solar system topic not treated at all is the planet Venus. Such traditional observing programs as dichotomy timings (phase anomaly) and reports of the ashen light are still of considerable interest and value. In the section on Jupiter, the authors show the jovian disk as a circle. This is inaccurate and may lead novice observers astray by tacitly encouraging sloppiness in their observations. (Remedy: use a 70° ellipse template, available in any art-supply store, to draw the elliptical jovian disk.)

Deep-sky related observing programs are also lacking in this book. Variable stars are well treated, and the authors mention surveying the brighter spiral galaxies for possible supernova outbursts in the same section — but that is all.

Non-professional contributions to our knowledge of deep-sky objects are less common than those concerning the solar system. But the chance to contribute *does* exist. Backyard astronomers can search the Milky Way for star chains and asterisms, count the stars and measure the drift diameters of open clusters, patrol for novae in globular clusters, monitor planetary nebulae nuclei for brightness variations and "structural" changes, and estimate the magnitudes of brighter quasars like 3C-273. All of these are challenging and worthwhile projects within the range of medium-size instruments.

Lastly, the book's most serious flaw is the omission of visual double star observation — including the virtually untapped and valuable area of measuring position angles and separations of close pairs with a filar micrometer.

But the book *is* valuable in what it *does* cover, and Sherrod and Koed have compiled a useful guide to observing. If future editions of the *Manual* deal with the omissions, the authors will then have written as complete a guide to the heavens as anyone could wish. Even as it now stands, the book has great value to all who go about this hobby systematically, and it will surely inspire observers to try out new areas of sky-watching. *James Mullaney.*

Solar-Skreen Sun Filters

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The best place to put a Sun filter is over the front of your telescope. First, it's the only safe place — if you put the filter at the eyepiece, the concentrated heat of the Sun is sure to crack or melt it. Second, even if nothing gets damaged, letting the Sun's full heat into the telescope tube will set up temperature differentials and air currents that will blur the image.

In order to protect your eyes, a solar filter has to reduce visible light and infrared and ultraviolet radiation by a factor of about one million. Dr. B. Ralph Chou, an eye-injury specialist at the University of Waterloo (Ontario) Optometry School, has tested a variety of Sun filters and found that smoked glass, layers of color film, and photographic neutral density filters are *not* safe. Welder's glass (#14) or two layers of fully exposed and developed conventional black-and-white film (but *not* chromogenic films such as Ilford XPL or Agfa Vario-XL) make safe filters, but aren't optically good enough to put in front of a telescope.

This leaves you with filters that use metal coatings on glass or plastic. The Solar-Skreen filter consists of two layers of thin plastic with shiny metal coatings on both sides of each. And since it has four separate coatings, it's unlikely that they would all be damaged at once and let undiluted sunshine reach your eye.

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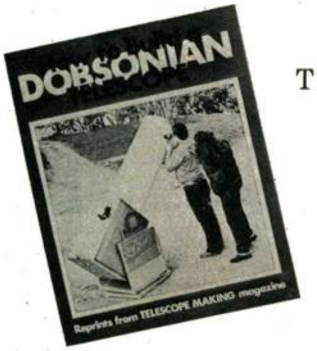

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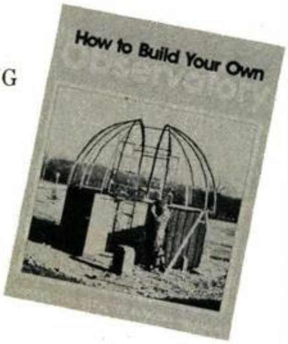

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unmounted version and built a rather Victorian-looking wooden cell for it. When I want to observe the Sun, I check the Solar-Skreen for pinholes or other defects, clamp it onto my 5-inch Schmidt-Cassegrain, aim the telescope by projecting the Sun through the finder, and then cap the finder so I won't accidentally look at the unfiltered Sun.

I'm rewarded with the finest view of the Sun I've ever seen through *any* equipment. At 30x to 70x, I've seen granulation all over the solar disk. Sunspots show sharp outlines with clearly distinct umbrae and penumbrae, and faculae glow near the edges. All these features are almost as easy to photograph as they are to see. The only drawback is that peculiarities in the Solar-Skreen's almost flat transmission curve color the Sun an electric blue — but you can adjust to this.

One advantage of buying an unmounted Solar-Skreen is that it is supplied oversize and square, so you get more than you need. In fact, a group of observers might want to pool their money, order a large sheet, and divide it up. A 10" square at $35 will make four 5" or nine 3" filters — or 100 1" squares to put in slide mounts for naked-eye eclipse watching. You can also save money by buying a filter smaller than the aperture of your telescope. Although Tuthill supplies full-aperture filters up to 20" across, it's rarely practical to use an aperture of more than 5" or 6" for daytime observing because of poor seeing. You could have a satisfying session with a 3-inch scope capped by a 3" piece of Solar-Skreen. *Michael Covington.*

Skywatchers of Ancient Mexico
Anthony F. Aveni
355 pages, hardcover, $30
University of Texas Press (1981)

European archaeo-astronomy has been studied for a long time, but that of the New World hasn't. Aveni's book surveys the astronomical knowledge of the Aztecs and Mayas revealed in writings, inscriptions, and monuments.

The New Solar System
J. Kelly Beatty, Brian O'Leary, and Andrew Chaikin, eds.
224 pages, hardcover, $19.95
Cambridge University Press (1981)

In twenty articles written by leading space scientists, this book addresses what we have learned about the solar system since the start of space exploration — and, in particular, how the picture has changed in the last few years.

Stellar Paths
Peter van de Kamp
155 pages, hardcover, $34.95
D. Reidel (1981)

Astrometry provides astrophysicists with hard data on the distances to stars, their positions and their masses — quantities that are bedrock to build elaborate theories upon — hence the abundance of multiple-term equations in the science. But this highly specialized discipline also has a strong following in the general public. Why? Because astrometrists are the scientists who will, someday soon, announce the discovery of the first extrasolar planetary system.

Subtitled "photographic astrometry with long-focus instruments," *Stellar Paths* is intended for the professional astronomer and accordingly it is not an easy read. It brings up to date the second part of van de Kamp's earlier work *Principles of Astrometry*, published in 1967.

Atlas of the Andromeda Galaxy
Paul W. Hodge
79 pages, hardcover, $50
University of Washington Press (1982)

The Andromeda Galaxy (M-31) is a familiar feature of the skies to most telescope owners. Generations of observers have collectively spent years gazing at its soft, faintly detailed glow. As you look into your eyepiece, it becomes *your* Andromeda Galaxy.

But there's also a different galaxy out there — that of the professional astronomer. He's eager to unravel its mysteries and explore its structure; after all, in many ways it seems to be a twin of our own. This book will appeal most directly to the professional — if only on account of its stiff price.

Hodge's *Atlas* has 41 black-and-white plates taken in blue light through the Kitt Peak 4-meter telescope. Globular and open clusters, dark dust nebulae, and stellar associations are all clearly marked on the negative reproductions of the plates. Four tables, one for each category, follow the photos, listing and describing the objects.

Comets and the Origin of Life
Cyril Ponnamperuma, ed.
282 pages, hardcover, $39.50
D. Reidel (1981)

Few professional astronomers would attribute the origin of life on Earth to comets, but this doesn't mean these balls of dust and ice have had no effect on the evolution of life. *Comets* reprints the papers given at a conference in October 1980.

The Moon — our sister planet
Peter H. Cadogan
391 pages, hardcover, $59.95;
paperback, $24.95
Cambridge University Press (1981)

This book is a comprehensive summary of the present state of lunar science. Starting with a view of "the Moon from a distance," the author discusses manned and unmanned lunar landers, lunar rocks and minerals, the regolith, global measurements, and "the Moon's history and future."

Solar Phenomena in Stars and Stellar Systems
Roger Bonnet and Andrea Dupree, eds.
591 pages, hardcover, $69.50
D. Reidel (1981)

The solar phenomena referred to in the title include magnetic field disturbances, coronal holes, mass loss, solar winds, and flares. This book records the papers given at a conference in 1980.

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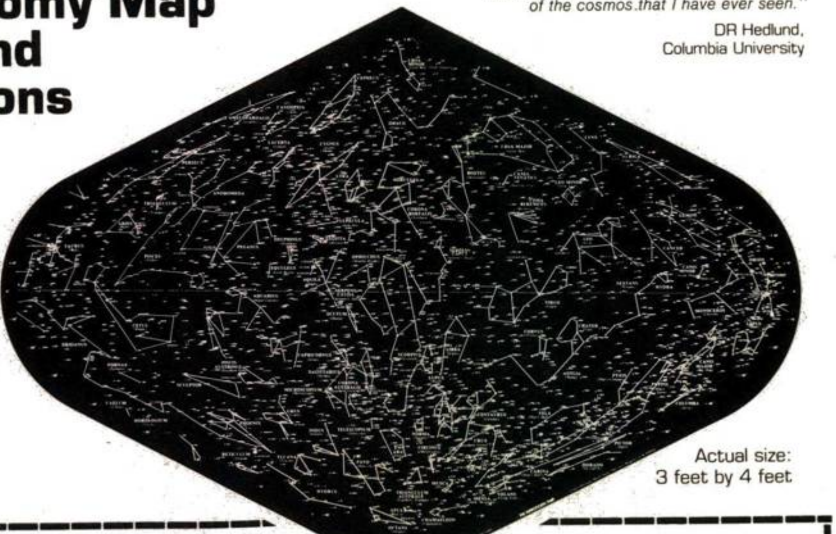

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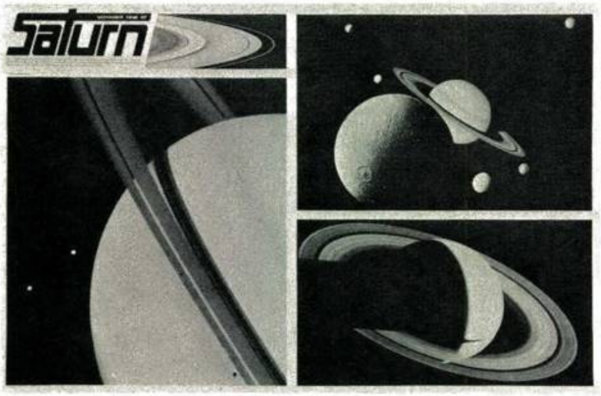

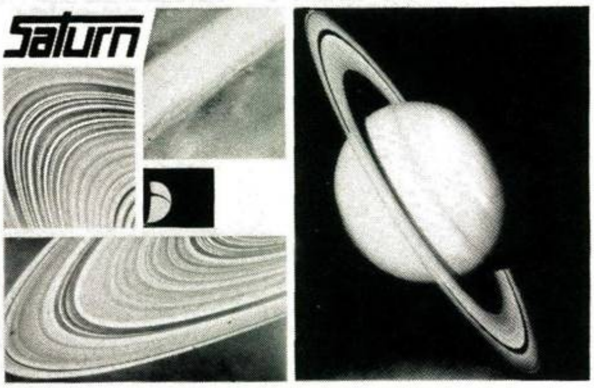

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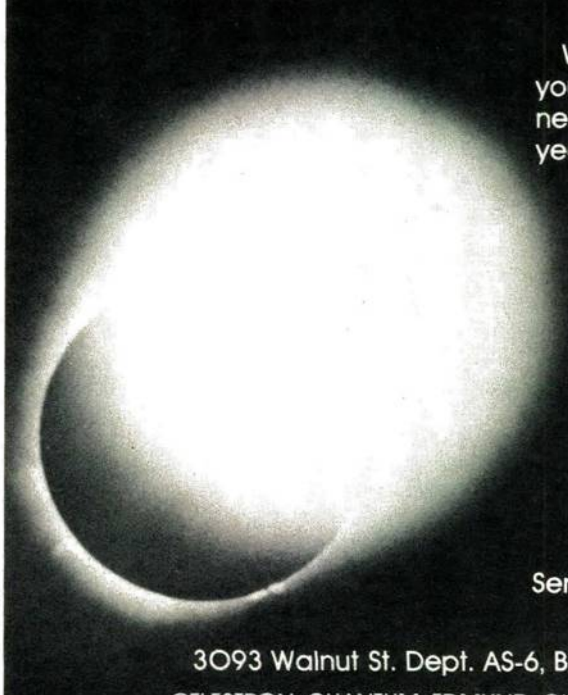

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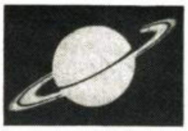

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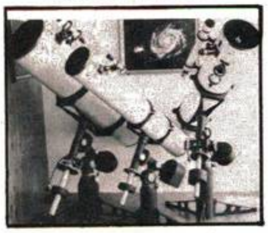

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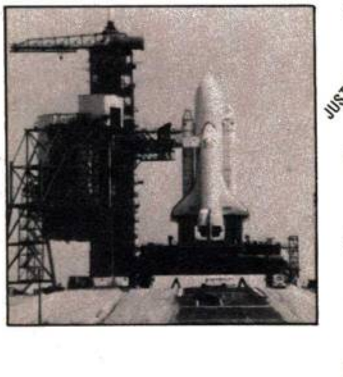

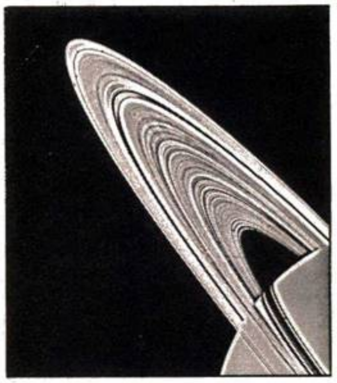

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Molecules between the Stars

by David Darling

Stripped of its rich interstellar medium, our Galaxy would be a vastly different place — dimmer, less colorful, and doomed to an early death as its stars age and flicker out. But with close to 15% of its total mass in the form of interstellar dust and gas, the Milky Way holds a good supply of raw material from which to create new generations of stars.

The places where new stars form — "stellar nurseries" — are among the most intriguing known to astronomy. In them, we can eavesdrop on the processes that occur as loosely aggregated matter coalesces into stars. Astronomers have found that, besides the expected gas and dust, giant clouds of molecular material are also an important part of the matter that goes into star formation. In addition, these clouds harbor substances from which even life itself may have begun. If our origins do not quite lie in the stars themselves, they may well lie in the spaces between.

Non-stellar content varies widely from one galaxy to the next. Elliptical galaxies, for instance, are almost devoid of interstellar material. Any gas or dust which has survived in them is now highly concentrated in their nuclear regions. At the other extreme, gas-rich irregular galaxies may store up to a quarter of their mass in the interstellar medium. Our own Milky Way lies somewhere in between and sports its generous quota of gas and dust in a thin equatorial disk.

The material between the stars, like the stars themselves, is almost entirely hydrogen and helium. These two elements, the simplest of all, make up the bulk of nearly everything from individual stars to the universe as a whole. Even with all the changes that have taken place since the Galaxy formed, the interstellar material — a mix of primordial matter left over from the Milky Way's birth and debris from more recent stellar explosions — is still largely hydrogen and helium.

Though these two elements may dominate overall, within very limited regions of the Galaxy the heavier elements, called *metals* by astronomers, may play key roles. The existence of terrestrial planets, for instance, testifies that metals and other heavy and highly-processed substances can be critically important on a local scale.

Atoms heavier and more complex than helium are created by fusion within the nuclei of massive stars — stars which speed through their life-cycles before a supernova explosion blasts the bulk of their heavy-element enriched contents into interstellar space. Galaxies like our own — containing a sizeable population of supernova-doomed heavyweight stars — are constantly adding to their supply of heavy elements. These by-products of stellar evolution slowly disperse and ultimately find their way into dense, collapsing clouds of gas and dust which become the precursors of a new generation of stars.

Pause for a moment and consider a few poignant facts about your origins. Planets condense from the nebulae that surround new-born stars. These nebulae are made from a mix of primordial matter and gassy dust contributed to by other generations of stars. In at least one case — on the planet we call Earth — life evolved from one of these nebulae. Just how special we are is conjecture at present, but the remarkable fact remains that nearly every particle within your body and mine was forged in the multi-million degree heat of a star's core — before it was hurled into space by a supernova explosion.

If life was created once under circumstances that seem common throughout the Galaxy, what does this say about its chances overall? Or, to rephrase the question, do the first building blocks of life always evolve on planetary surfaces? Do basic biochemicals, like amino-acids, occur only — or mainly? — or seldom? — in environments like those of the primitive Earth?

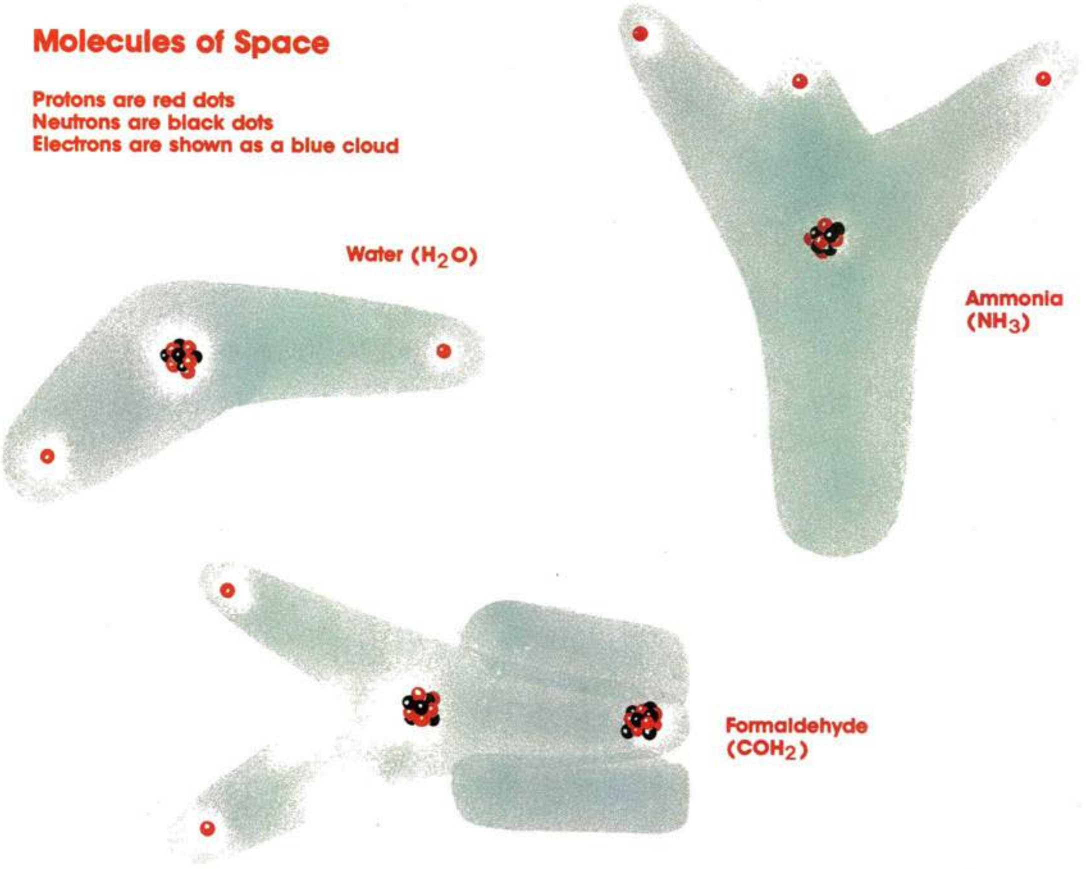
No one can give a hard and fast answer to these questions, but to start working on one, we need to know more about the structure of giant molecular clouds and the events taking place within them. These clouds are fascinating — in a very real sense, they are the chemical plants of the Galaxy, makers of an impressive variety of common and exotic molecules.

Crossing the meridian about 6 p.m. on mid-March evenings is the magnificent and familiar constellation Orion. Just a little way south of Orion's three-starred belt, a faint patch of light glows, barely discernible to the naked eye. If we could somehow zoom 1500 light-years toward it, that faint patch would become a brilliant, space-filling web of light, extending gleaming tendrils of hot gas to the periphery of our vision.

In it, bright filaments and loops span out from a compact, central cloud — their delicate forms glowing with the characteristically ruddy light of ionized hydrogen. Driving the Orion Nebula's glow is a quartet of very hot, very young stars known as the Trapezium cluster. These O and B-type stars are still actively "turning on" the hydrogen gas in their part of the nebula.

They do it by flooding the gas with high-energy ultraviolet photons. These particles momentarily strip — or *ionize* — hydrogen atoms of the one electron that each has.

Like many of its bright cousins scattered throughout the plane of the Milky Way, M-20, the Trifid Nebula, consists of ruddy luminous ionized hydrogen gas crossed by dark lanes of molecular material; a bluish dust nebula reflects the light of a hot star. From this gassy dust, new stars are born. Photo courtesy of Kitt Peak National Observatory.



Molecules of Space

Protons are red dots
Neutrons are black dots
Electrons are shown as a blue cloud

But no sooner does an electron fly off, than the ionized hydrogen atom recaptures one of the many stray electrons whizzing by. As it does, each newly re-combined hydrogen atom releases a tiny blip of ruddy light. The blips are insignificant individually, but their number is so great that they collectively produce the steady luminous glow you see in a telescope. In certain places where the density is too great — the aptly-named "fish-mouth" for instance — there's enough material to block the flow of atom-smashing photons from the Trapezium stars. These regions appear dark because they are deprived of energizing radiation.

This stellar quartet embedded in the heart of the nebula formed only recently — within the last few hundred thousand years — out of the very gas cloud it illuminates. Because its four stars are massive and hot, their lives will be short. All too soon — within a few million years at most — their fires will run low and they will wink out. But elsewhere in the nebula, embryonic protostars are nearing the time when their own nuclear fires will ignite. As long as the Orion Nebula keeps a plentiful supply of gas and dust, new generations of stars will form within it.

To the astrophysicist who studies how stars are born, the Orion Nebula has become what the famous Crab Nebula is to observers of supernovae: a vast natural laboratory where fascinating and novel physical processes are constantly on show. We're fortunate to have such a large and well-equipped stellar nursery close at hand. Not only can we detect the signs of new stellar life within the core of the nebula, but we can also study in great detail the structure of the surrounding gas and dust complex.

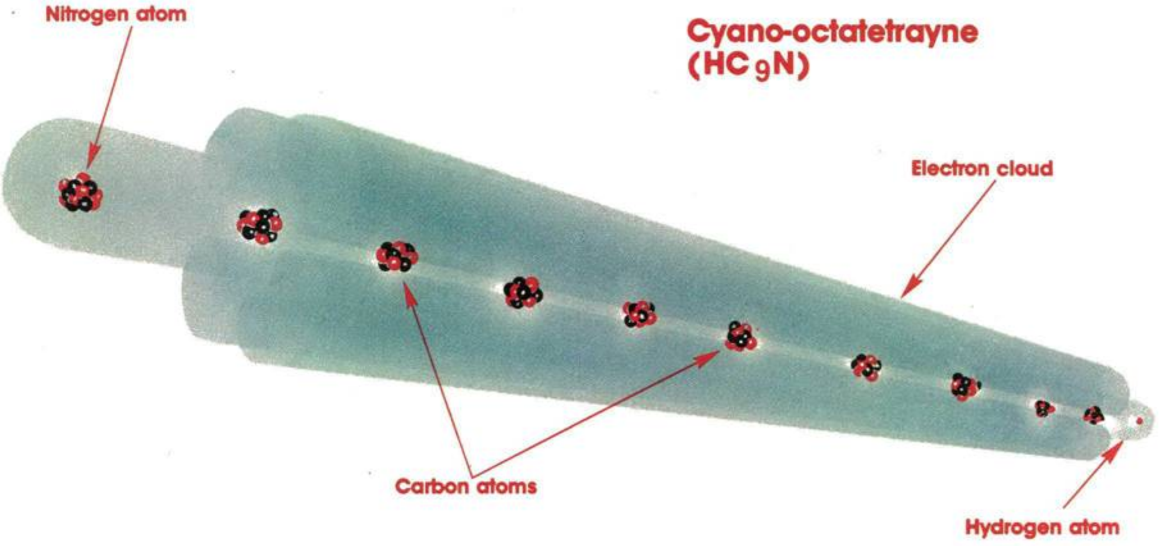
For example, behind the visible Orion Nebula lurks a dark cloud of cold hydrogen. This is not the ionized hydrogen, the luminous ruddy plasma, of the visible nebula, nor is it an inert mix of individual neutral hydrogen atoms. The black tongue of matter that forms the fish-mouth and extends out behind the nebula is composed primarily of molecular hydrogen — two hydrogen atoms bound together.

This molecular cloud is particularly dense in two places, one of which lies fairly close to the Trapezium cluster itself. Infrared "hot spots" — the tell-tale signs of stars in formation — gather around each. Astrophysicists think one of these infrared sources (the so-called Becklin-Neugebauer object) is perhaps the most likely candidate to be a protostar far advanced in its birth-process.

How do the giant molecular cloud and the visible, ionized nebula relate to each other? The two structures may actually be touching, with the fierce ultraviolet photons from the Trapezium stars already gnawing into the cold molecular cloud. About the time the energy-squandering, short-lived Trapezium stars flicker out and their ionized domain reverts to its neutral and invisible state, the molecular cloud will clear away and reveal its new-born protostars. These, in their turn, will become the new beacons of Orion, lighting up virgin regions of the nebula and delighting future generations of stargazers.

Although the Orion Nebula is spectacular, it's far from unique. Several close cousins — such as M-17, the Omega

A rich cloud of ionized hydrogen gas, the Omega or Swan Nebula, M-17, also harbors a cluster of young stars. As they evolve, the stars will enrich the gas from which new generations of stars will form. Photo courtesy of Hale Observatories.



Nebula, and M-20, the Trifid Nebula — exist in other parts of the Galaxy. Furthermore, these appear to be just as active in the process of spawning — in the manner of the mythological Phoenix — brilliant new stellar life from the ashes and dust of old stars.

The first clues to understanding the mechanism of star formation — and perhaps even the deeper mystery of the origin of life — are woven into the complex tapestries of the huge and dense molecular clouds that pervade our Galaxy. Most of these inhabit the galactic spiral arms, regions plentiful in gas and dust, and are often close to the ionized nebular birthplaces of new stars. Astronomers can see that several of the more prominent molecular clouds are intimately associated with these gaseous nebulae.

The very idea of molecules forming in interstellar space may appear rather strange at first. Even though we have studied the properties of over a million different species of molecules from water to DNA, it's clear that conditions on Earth are vastly different from those prevailing in the gulf between the stars. Space is an environment in which particle densities are so thin they make a mockery of the best vacuums achieved in earthly laboratories. It is also an environment bathed in high-energy ionizing photons from hot stars. Such conditions offer little hope that complex and delicate substances can survive.

But this overlooks an important factor: the denser molecular clouds, those associated with star formation, harbor a good deal of dust — dust that's very different from the domestic variety. Typically, cosmic dust consists of very fine grains of ice-coated silicate or graphite, each only about one hundred thousandth of a centimeter across.

This dust is opaque, and the silicate and graphite dust particles that make it up absorb energy-loaded ultraviolet photons streaming from nearby stars — photons that otherwise would smash the fragile molecules as fast as they formed. As they soak up this radiation, the dust particles become warmer — though at 100 K they are still very cold by everyday standards. When molecules bounce off the warm grains, they carry away some of the grains' heat. Eventually, the entire molecular cloud will share, secondhand, in the warming effect of the surrounding high-energy starlight. The giveaway observational "signature" — the physical signal that a molecular cloud has been warmed by ultraviolet light from local stars — shows up as far-infrared or microwave radiation.

The dust also acts as an effective thermal transformer which enables delicate molecules to coexist freely with high-energy, ionizing radiation. An unfortunate side-effect for astronomers is that optical observations of molecular regions around nebulae are difficult or impossible because of the obscuration from dust.

We've seen that dust can ensure the survival of molecules in space. But what of the molecules' formation in the first place? How does this come about? Two basic mechanisms are probably at work — the first again involves dust. A dust grain may act as a "sanctuary" to which individual atoms or simple molecules can attach themselves and in time become bound to other atoms settling on the same grain. Astronomers think that these surface reactions occurring on dust particles are especially important in forming hydrogen molecules. The second mechanism, probably responsible for the building of more complex substances, is the collison of simple atoms with molecules here and there throughout the cloud.

In abundance, molecular hydrogen (H_2) dominates in molecular clouds, just as atomic hydrogen (H) dominates in the universe at large. But hydrogen is the simplest of all molecules. As you might expect, the greater the complexity of an interstellar molecule — the more atoms it contains and the more bonds between them — the rarer it is likely to be. Complex structures take longer to form and need more special conditions than do simple structures. This affects us observationally because if a molecular species is rare, it's unlikely to have a strong spectral signature and will therefore be difficult to detect. The result is that our knowledge of interstellar hydrogen molecules is far better than that of the more exotic types.

Despite these difficulties, the evolution of increasingly sensitive and sophisticated instruments over the last two decades has led astronomers to find molecules of steadily increasing complexity. In 1963, the hydroxyl radical (OH) was detected. Toward the end of the 1960s, astronomers added the familiar names of ammonia (NH_3), water (H_2O), and formaldehyde (H_2CO) to the list of known molecules. The detection of formaldehyde, the pungent preserver of biological specimens, was especially significant, as it marked the first organic molecule found in interstellar space.

The early 1970s saw a further burgeoning of molecular astronomy. Several diatomic molecules were found — silicon monoxide (SiO) and silicon sulfide (SiS), carbon monoxide (CO) and carbon sulfide (CS), and poisonous cyanogen (CN). Then organic molecules of increasing complexity began to appear — including methilidene (CH), ethynal (CCH), acetylene (C_2H_2), formic acid (HCOOH), acetaldehyde ($HCOCH_3$), and ethyl alcohol (C_2H_5OH). To date, a grand total of 54 molecular species have been identified in interstellar space.

Borne on the surface of tiny graphite or silicate particles and having incredibly low densities even in the thickest molecular clouds, these substances each display a characteristic radio-frequency spectrum that terrestrial astronomers can recognize. Molecules produce their individual and unique spectra in one of three ways. Carbon monoxide, hydrogen cyanide, methyl alcohol, and certain other species emit radiation as they undergo transitions between rotational states of the molecule. A second group, including the hydroxyl radical and formaldehyde, absorbs radiation of specific wavelengths from bright background sources. Lastly, molecules such as water and silicon monoxide beam out intense radiation in a maser-like process.

If the environment of an interstellar cloud is so very different from that of a laboratory here on Earth, what does that imply for the molecules that form there? Is there any such thing as an "alien" molecule? Interestingly enough, the answer is yes. A whole class of organic molecules which have proven extremely difficult or impossible to manufacture on Earth have turned up in these clouds. To understand further the differences between the alien molecules and those readily produced in the lab, let's review some basic chemistry of the carbon atom.

Comprised of a nucleus of six protons and six neutrons and surrounded by a cloud of six electrons, the carbon atom has a surprisingly simple structure. Yet its ability to link with other atoms and form strong and stable chains of almost limitless length and variety enables it to construct fantastically complex molecules. Many of these molecules are the building blocks of terrestrial life-forms. In fact, "organic" chemistry is synonymous with carbon chemistry.

Carbon has a combining power — a *valence* — of four. This means that each carbon atom's outermost four electrons are available for sharing with other atoms in an arrangement known as *covalent bonding*. Linking two carbon atoms together can use up one, two, or even three of the valence electrons from each atom, depending on whether the bond is single, double, or triple. In other examples, carbon-hydrogen bonds use up one electron from each atom, and carbon-oxygen and carbon-nitrogen bonds require a contribution of two electrons from each partner.

With this in mind, we're ready to examine some of those "alien" molecules. The simplest member of this new molecular family is hydrogen cyanide (HCN), a familiar chemical in terrestrial laboratories. The more complex members of the series are made up of two or more carbon atoms in a chain linked at one end to a hydrogen atom and at the other to a nitrogen atom. To use up all the bonds and arrive at a stable substance, an odd number of carbon atoms must be involved.

Discovered next in the series was cyanoethyne (HC_3N), a molecule fairly abundant in interstellar clouds. But then a problem arose: the third member of the family, anobutadiyne (HC_5N), never existed on Earth. Without knowing what its spectrum looked like, astronomers couldn't search for it.

In 1976, anobutadiyne's rotational spectrum was measured on Earth for the first time. Later that same year, astronomers announced the discovery of HC_5N in a dark cloud in Sagittarius. Two years later, the episode was repeated with cyanohexatriyne (HC_7N) being detected in Heile's Cloud B, a local molecular complex, following its synthesis and spectral evaluation here on Earth.

The heaviest molecule so far discovered in space is cyano-octatetrayne (HC_9N), a companion of HC_7N in Heile's Cloud B. It has never been synthesized on Earth. Cyano-octatetrayne's spectral characteristics were deduced with good accuracy from the characteristics of the simpler members of its chemical family. Astronomers have found, not unexpectedly, that every increase in molecular complexity is accompanied by a sharp drop in abundance and in emission strength. The discovery of additional molecules in this oddball series must await the development of more sensitive instruments.

We still don't know how the long-chained "HC_xN" molecules are manufactured in molecular clouds. And given that a substance like HC_9N — so unstable it has never existed on Earth — can be formed in space, it's curious that no ring compounds of carbon, such as benzene, have ever been detected between the stars. The chemical plants of the Galaxy apparently favor a very different blend of molecules than we find on Earth.

In any case, substances of considerable complexity have already been found within interstellar clouds and the future promises more exciting revelations for the molecular astronomer. Even simple biochemicals — amino acids, for example — may someday be detected in the denser, more sheltered regions of molecular clouds. Certainly the building blocks of the amino acids — aldehydes, nitriles, and water — exist in space already. In a recent bold and controversial hypothesis, Sir Fred Hoyle and Jayant Narlikar have suggested that biochemicals, formed in space and carried on the dust particles of a nebula around a protostar, could become the seeds of life for a virgin planet.

*****

Molecular complexes, the most massive objects known in the Galaxy, each hold as much material as several hundred thousand Suns. On the macrocosmic level, they are essential to the galactic star-making machinery, nurturing the embryos and infant forms of stars. And at the microcosmic level, these huge gas and dust clouds harbor a rich collection of molecular substances both common and exotic by Earth standards. It is almost certain that, if we probed back far enough, we could call one such cloud our forebear.

David Darling graduated from the University of Manchester (U.K.) with a doctorate in physics. His last article for ASTRONOMY, "Universe 0:00," appeared in the November 1980 issue.

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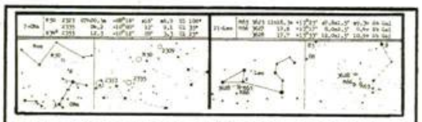

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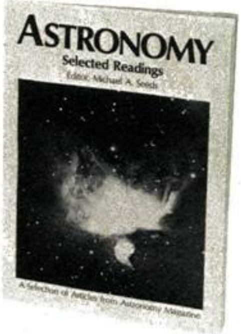

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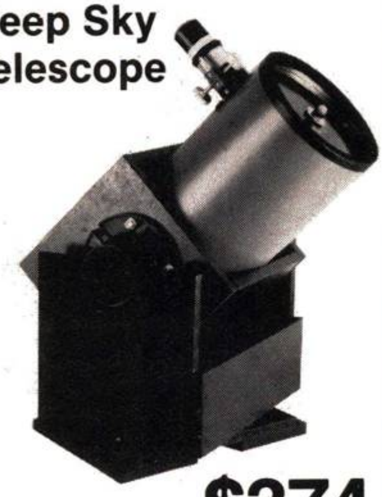

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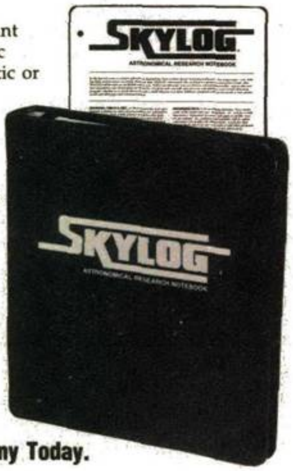

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lynx

Mercury

Mercury will be visible in the morning sky for the first week or two of March, but it will be so low it will be difficult to see. Thereafter, it will be lost in the blaze of sunlight until, having passed through superior conjunction on April 11, it will emerge in the evening sky late that month.

For the sharp-eyed — especially on the west coast — Mercury will pass very close to the 5.5 magnitude star 42 Aquarii at about 14:41 UT on the 14th. The distance will be only some 42″ of arc.

Venus

Reaching its highest elevation for this morning apparition around the first of March, Venus is prominent in the east-southeast in the hour before sunrise. This month it traverses the constellation of Capricornus and begins a steady northward movement along the eastern horizon that will continue until the beginning of August. During this time, Venus' elevation will remain relatively constant at some 10° to 15° (45 minutes before sunrise).

During March the planet will be shrinking in your eyepiece — from 37″ of arc on the 1st to 25″ on the 31st. But as it pulls away from us, its illuminated portion grows steadily from a crescent 31% lit at the beginning of the month to a just less than half lit 49% at the end. Greatest elongation is on April 1.

At about 2:29 UT on the 8th, Venus will pass less than 15′ of arc south of 3.2 magnitude Beta (β) Capricorni.

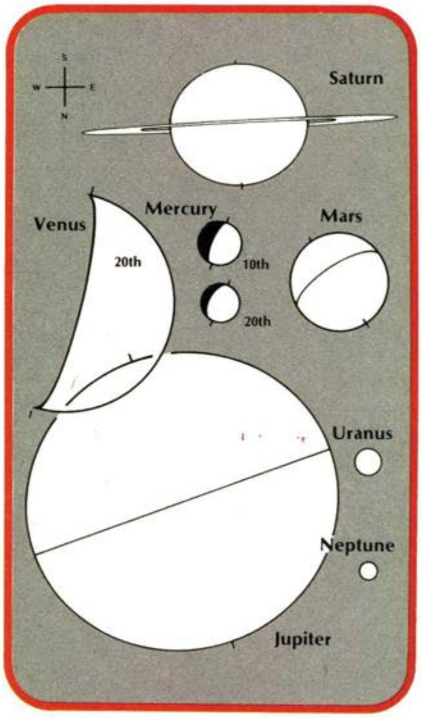
Earth

The vernal equinox this year comes at 22:56 UT on March 20. From our viewpoint on the moving Earth, the Sun appears to cross the celestial equator northbound, heading toward its highest declination of +23° 27′ which it will reach on June 21.

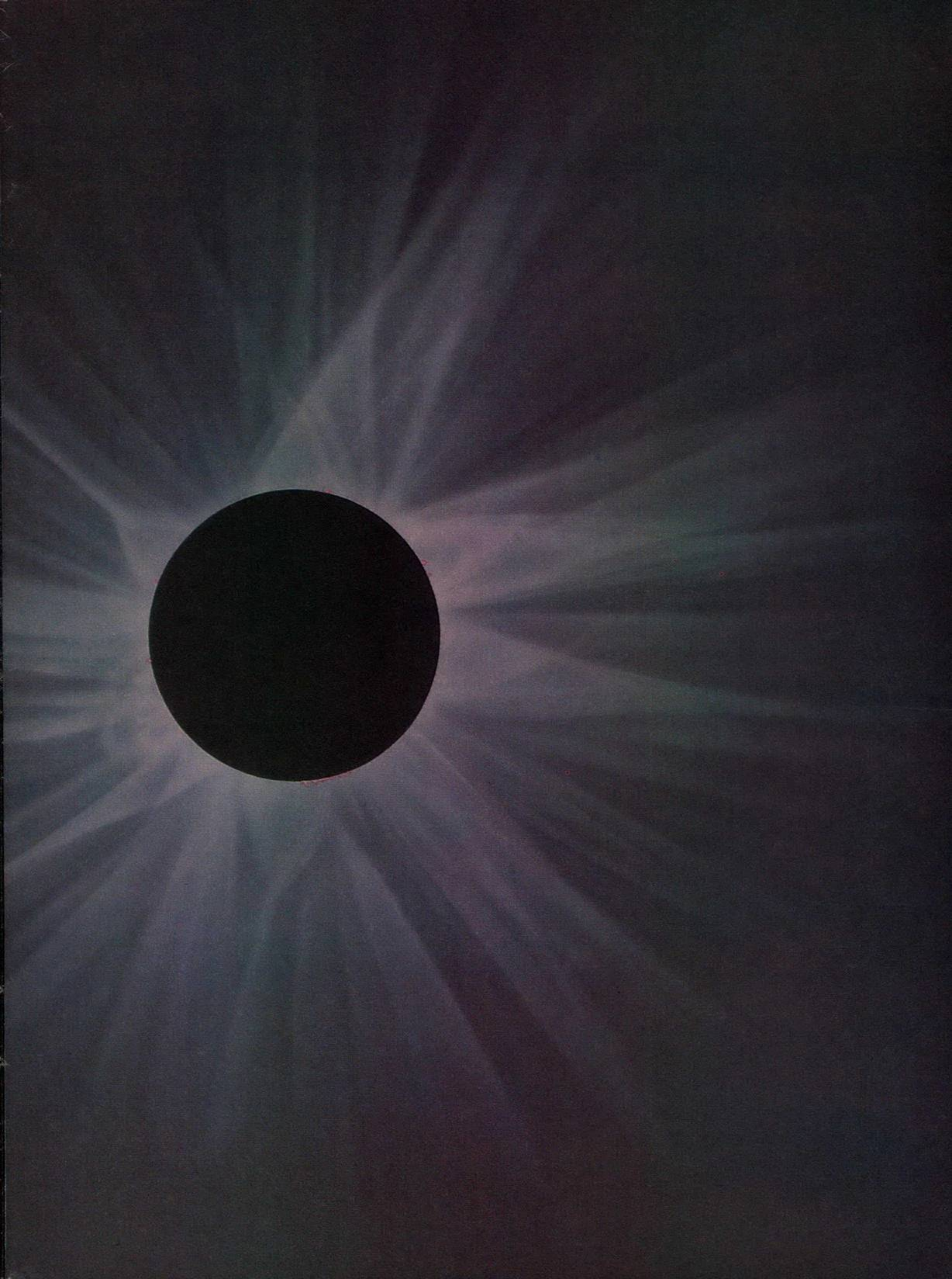
Mars

The Red Planet comes to opposition on March 31 at 10h UT. As oppositions go, this isn't a very good one: Mars passed its aphelion on January 12 and on March 31 it will lie some 95 million kilometers away. This distance reduces its apparent size to just 14.6″ of arc.

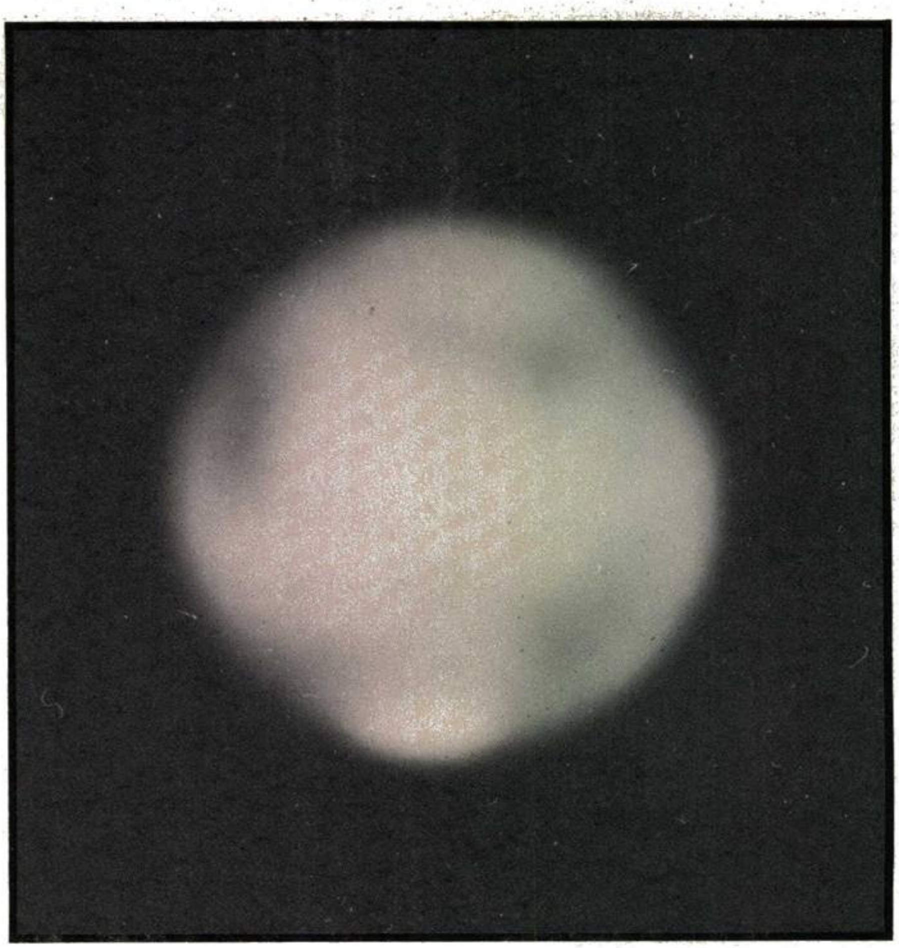
This doesn't make for a very impressive view. In fact, many people seeing Mars for the first time through a telescope are shocked by how small it appears: Surely this little thing isn't . . .? How can anyone see *anything* on that tiny disk? There's nothing we can do



Akira Yotsumoto of Tokyo, Japan, traveled to India to view the February 1980 solar eclipse. He observed with 7 x 50 binoculars and took a number of photos through a 500mm lens. After returning home, he used his observations and photos as "memory-aids" and created this striking airbrush rendering.



Left: M-101 in Ursa Major is an open spiral galaxy about 15 million light-years away. Leo Henzl took its photo with an 8-inch f/10 Schmidt-Cassegrain and a cold camera. Right: Don Parker took this photograph of Mars in February 1980 at its last opposition. The planet will be at opposition again on March 31.



until the "cycle of oppositions" brings about two favorable perihelic oppositions in 1986 and 1988. Mars' apparent size will then be nearly twice what it is this year.

But its small size is no reason to pass up Mars as a telescopic object. Instead, take every chance you can to haul out the scope and look the planet over. Try to give yourself at least a half-hour of observing — it will take that long for your eyes to become sensitive to its features. Soon, you'll recognize markings you would have missed with just a quick glance.

Last month we suggested you try a blue filter to help you pick out atmospheric features like clouds. A red filter will help you see through the martian atmosphere and make out the planet's surface markings. Try an orange filter, too — or a green or yellow — and see what these colors reveal.

Asteroids

1 Ceres (magnitude 7.4) is in north-central Libra. Its positions:

10th: 15h 41m 18s, -9° 46.8'
20th: 15h 43m 32s, -9° 49.0'

Ceres rises around 11:30 p.m. local time in the middle of March.

2 Pallas (7.3) is retrograding in Virgo. Its positions:

10th: 13h 28m 29s, +06° 33.4'
20th: 13h 23m 45s, +10° 13.3'

Pallas rises about 8:30 p.m. local time on March 15.

3 Juno (11.1) lies near the border of Serpens Cauda and Scutum. Its positions:

10th: 18h 12m 29s, -10° 49.6'
20th: 18h 20m 33s, -10° 11.8'

Juno rises about 2:30 a.m. local time at mid-month.

4 Vesta (7.7) is in eastern Sagittarius, east of the "teapot." Its positions:

10th: 19h 34m 04s, -20° 11.0'
20th: 19h 53m 37s, -19° 39.8'

Vesta rises an hour and a half after Juno: around 4:00 a.m. local time on the 15th.

16 Psyche (11.3) lies near the Leo/Sextans border. Its positions:

10th: 10h 41m 52s, +09° 12.2'
20th: 10h 34m 49s, +10° 00.7'

Psyche sets about 5:15 a.m. local time in the middle of March.

All asteroid positions are in 1950 coordinates to make plotting them on a sky atlas easier.

Jupiter

Even a quick look at Jupiter in a telescope reveals the distinctly oval shape of its disk. There are two reasons for this: first, the planet spins rapidly — one jovian day lasts just 9h 55m. Second, Jupiter is largely gaseous, so its components are as free as water to take whatever shape its whirling equilibrium demands.

Because of Jupiter's rapid rotation, matter at its equator moves at about 12 kilometers per second — a phenomenal speed. Such a high speed bulges Jupiter's equatorial diameter to more than 8000 kilometers wider than its polar diameter — a flattening of about 1/16. And centrifugal force reduces the surface gravity at the jovian equator to only 93% of what it is at the poles.

As you stare into your eyepiece, let your mind's eye wander out to those streaks and whorls of racing clouds. Jupiter doesn't look very large in the eyepiece, but it is large enough to hold 1,316 Earths and it has a mass equal to 318 of our worlds.

Saturn

Just east of Mars, Saturn is nearing its April 9 opposition — just 10 days after Mars'. Also like Mars, Saturn appears small — but makes a fine sight all the same! Few can resist its tiny, perfect beauty.

Saturn's rings have about the same apparent extent as the disk of Jupiter — 43" of arc — and the planet measures about half that, or 19". When the rings are not tilted too far away from edge-on (currently, they're only about 11° to our line of sight), the oval shape of Saturn is very distinct.

Rotating nearly as fast as Jupiter — once every 10h 39m — Saturn is the more oblate of the two: 1/10 as opposed to 1/16. And, just as with Jupiter, its equatorial gravity is less than that of its poles. In Saturn's case the reduction is 16%, and the planet's equatorial diameter extends more than 11,000 kilometers farther than the polar. Saturn could encompass 755 Earths and it has enough mass to make some 95 Earths.

Uranus

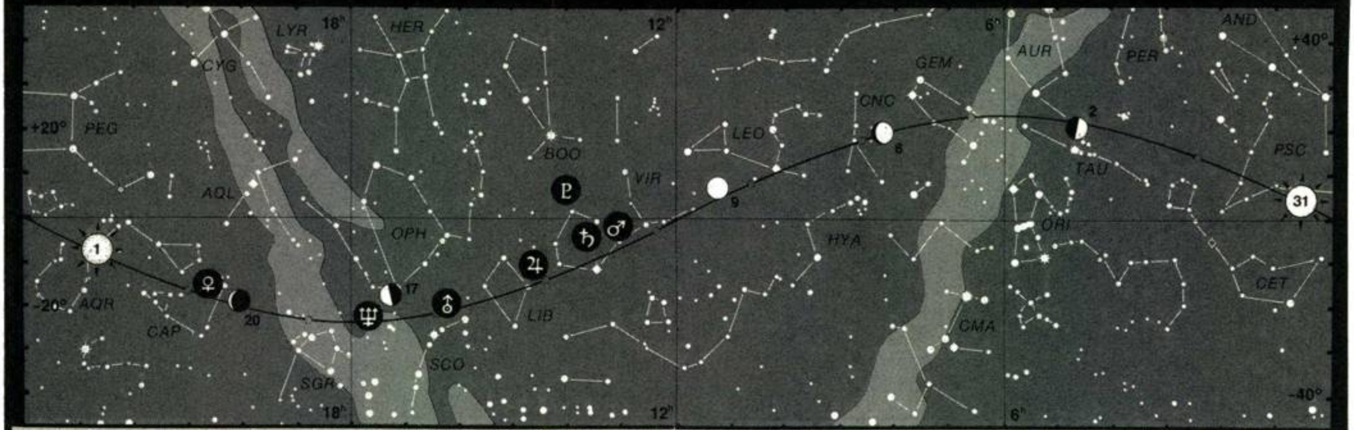
During March, Uranus lies only 1 1/3° south of the 4.3 magnitude star Nu (ν) Scorpii and about 4 minutes of R.A. east of 4.3 magnitude 10 Sco, also known as Omega^2 (ω^2) Sco. If you center your telescope on Omega, focus with a medium-power eyepiece, and then let the stars drift through the field of view, 4 minutes later you'll see Uranus as a small greenish disk.

Neptune

Neptune's path in March will take it as far to the east as it will get until late December. On March 29th, the distant planet is stationary in right ascension.

The easiest way to locate Neptune is to find 6.6 magnitude 52 Ophiuchi, offset your scope about 10' of arc to the south, and let the Earth's rotation bring it into view — Neptune will show up in 13 minutes. The alternative is to use 4.9 magnitude 58 Oph as a "jumping-off"

planetary data march 1982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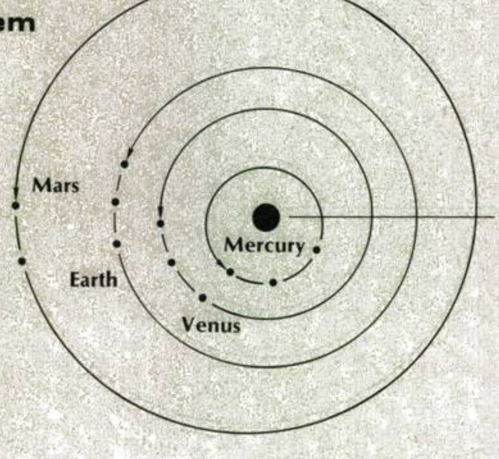
inner solar system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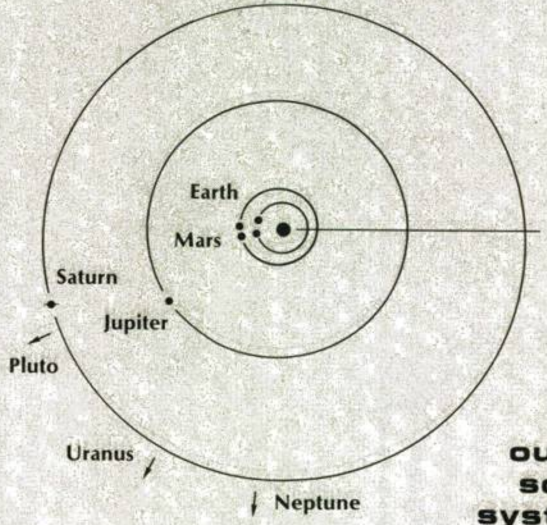

Earth
Mars
Saturn
Jupiter
Pluto
Uranus
Neptune

outer solar system

		Date	Mag.	Angular Size	% Illum.	Distance (AU) from: Earth	Sun	Longitude: Heliocentric	Ecliptic	R.A. (1982.3)	Dec
Sun		1	-26.8	32.3′	—	0.99	—	—	340°05.0′	22h 46.4m	- 7°47.5′
		15	-26.8	32.2′	—	0.99	—	—	354°05.1′	23h 38.2m	- 2°21.2′
		31	-26.7	32.1′	—	1.00	—	—	9°57.7′	0h 36.6m	+ 3°56.5′
Mercury	☿	1	+0.3	6.7″	62%	1.00	0.46	237°31.0′	312°58.9′	21h 03.9m	-17°19.5′
		15	0.0	5.7″	78%	1.18	0.46	276°19.7′	331°24.2′	22h 18.1m	-12°44.8′
		31	-0.7	5.1″	93%	1.32	0.40	327°56.3′	357°59.6′	23h 57.4m	- 2°32.9′
Venus	♀	10	-4.3	33.2″	36%	0.51	0.72	198°13.6′	304°49.6′	20h 25.8m	-14°59.4′
		31	-4.1	25.2″	49%	0.67	0.72	231°54.8′	323°07.2′	21h 41.4m	-12°13.8′
Mars	♂	15	-0.8	13.7″	99%	0.68	1.65	182°59.9′	195°29.8′	13h 04.1m	-3°19.8′
Jupiter	♃	15	-1.9	41.9″	100%	4.70	5.44	212°16.1′	219°18.3′	14h 31.3m	-13°24.9′
Saturn	♄	15	+0.6	19.0″	100%	8.76	9.66	198°05.9′	200°17.3′	13h 20.8m	-5°34.3′
Uranus	⛢	15	+5.9	3.7″	100%	18.51	18.87	241°46.1′	244°07.4′	16h 10.7m	-20°53.9′
Neptune	♆	15	+7.8	2.4″	100%	30.31	30.27	265°06.7′	266°30.7′	17h 47.0m	-22°07.4′
Pluto	♇	15	+13.8	—	100%	29.17	29.98	205°19.7′	205°55.6′	14h 03.1m	+6°12.6′

moon data

First Quarter	March 2 at 22:15
Full Moon	March 9 at 20:45
Last Quarter	March 17 at 17:15
New Moon	March 25 at 10:17
First Quarter	April 1 at 5:08
Perigee: March 4 at 5h	369,900 km
Apogee: March 17 at 5h	404,300 km
Perigee: March 29 at 6h	367,700 km

universal time

Astronomers the world over use an unambiguous system of time reckoning — Universal Time (UT) — based on a 24 hour clock. Times in The Backyard Astronomer are UT unless otherwise noted. To convert UT into your local standard time, subtract the following number of hours for each time zone: EST, 5; CST, 6; MST, 7; PST, 8; Alaska and Hawaii, 10. For example, if an event is to happen at 03:00 hours UT on January 2, then EST for the event is 10 p.m., January 1. Likewise, 03:00 UT on March 5 becomes, in PST, 7 p.m., March 4.

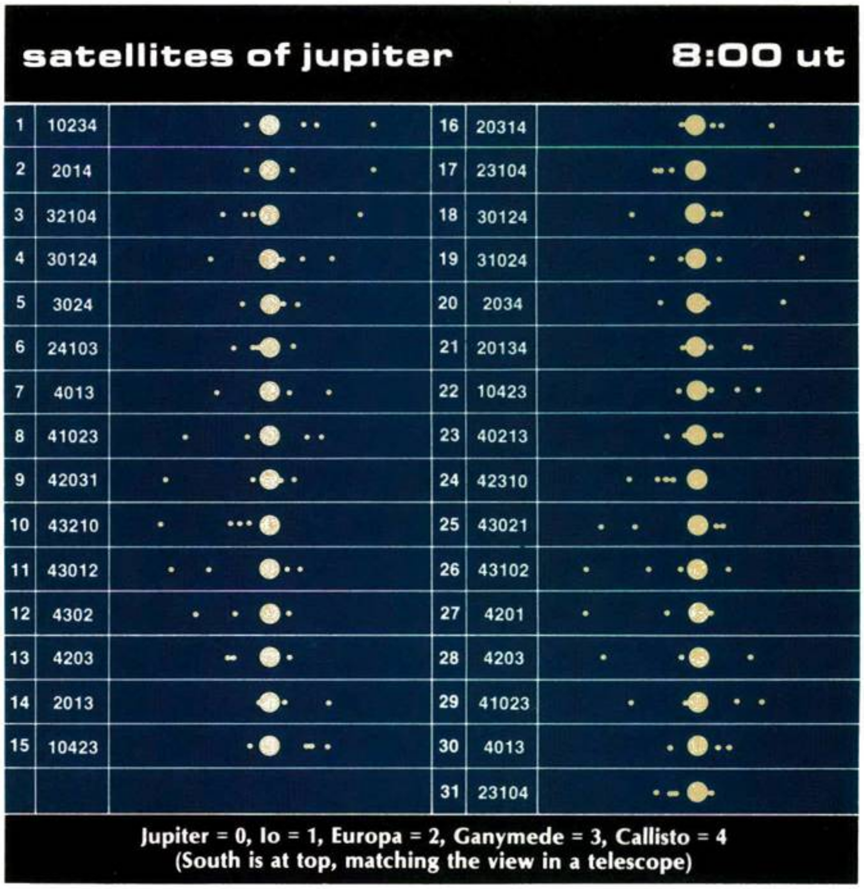
Above: A reflective convex surface makes an excellent "all-sky" lens. Jussi Salmi pointed his camera at such an object to capture this aurora over his native Finland. Overleaf: Herbert Hirsch's 45-minute exposure of a star-party wins the March "Best Astro-Photo" award. He used a 16mm fish-eye lens and 400 ASA film.

star. Center it, then scan some 25′ to 30′ of arc south. A 5-minute wait will bring Neptune into view.

close-up on lynx

The parade of bright planets in March and the dearth of prominent constellations make this a good month to sharpen your planetary observing skills. But if you get tired of squinting into your eyepiece trying to detect the fleeting surface features of Mars or Jupiter, focus in on Lynx and do some double star observing to refresh your over-worked eyes.

Lynx is a large circumpolar constellation — ranking 28th in size of the 88 constellations — but it is also very faint. Look between Auriga and Ursa Major on a dark night and try to trace its outline. Webb in his venerable manner described Lynx as "a trouble-

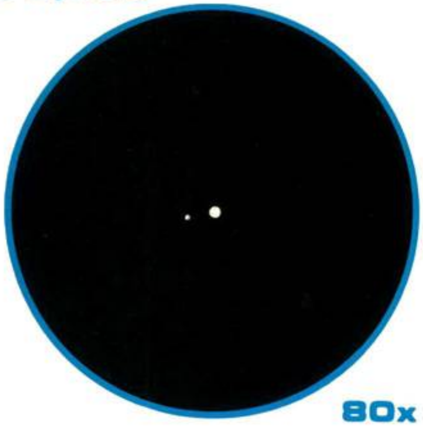


satellites of jupiter 8:00 ut

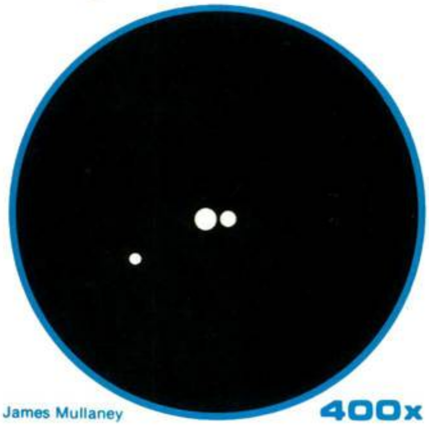
1	10234	16	20314
2	2014	17	23104
3	32104	18	30124
4	30124	19	31024
5	3024	20	2034
6	24103	21	20134
7	4013	22	10423
8	41023	23	40213
9	42031	24	42310
10	43210	25	43021
11	43012	26	43102
12	4302	27	4201
13	4203	28	4203
14	2013	29	41023
15	10423	30	4013
		31	23104

Jupiter = 0, Io = 1, Europa = 2, Ganymede = 3, Callisto = 4
(South is at top, matching the view in a telescope)

5 Lyncis



12 Lyncis



James Mullaney

some constellation, excepting with an equatorial mounting, as there are few conspicuous leaders among the number of tolerably considerable stars, which are puzzling in the finder. The beauty of its pairs will, however, reward a persevering observer."

Persevering is the key word here, for although the grouping is faint there are many double and multiple stars, one galaxy, and even a globular cluster bright enough to show up in backyard scopes. All you need is the time and patience.

Lynx's Alpha, sometimes called **Alsciaukat**, is a 3.1 magnitude type M star lying only 155 light-years away. It is 110 times brighter than our Sun, but its distance makes it only a fairly bright object. If you can't find it with your naked eye, take Webb's suggestion and use your setting circles. You'll find it at 9h18m,+34°36'.

Next in line for those with small telescopes is **19 Lyncis** — a trio of stars of magnitude 5.6, 6.5 and 8.0 at large separations of 15 and 215 seconds of arc. The two close stars form a long-period binary, but the third star is not associated with that system. You can easily see the separation in a small refractor at low power. The famous observer Smyth thought the brightest star was white, and the other two "pium colored." He was using a six-inch refractor, so the colors may appear different in your scope.

If you want to see a magnitude contrast as well as different colors in a double star try **5 Lyncis**. Barns described the brighter of these two as "a pendant ruby." Actually it is a fifth magnitude orange giant paired with a much fainter eighth magnitude companion 96 seconds of arc away.

For a pair of equal magnitude, take a glance at 20 Lyncis. The two components are 6.6 and 6.8 and are only 15 seconds of arc apart. This pair is striking even in the smallest scopes. Barns thought they were both silvery colored and in a very barren section of sky. Even if you have a large scope, try looking at this double. It will blaze in your eyepiece like two eyes in the night.

One of the real showpieces of Lynx is **12 Lyncis** — a double with a fifth magnitude primary and a sixth magnitude companion — only 1.7 seconds of arc away. Just 8" away is a third star that some observers claim is connected. This multiple system is a test for a three-inch aperture and is easier to split in a four-inch at 100 power — provided there is good seeing. If the atmosphere is very steady, give this multiple as much magnification as it can stand. It will even fit in the field of an 8-inch at 400 power. The colors seem to be yellowish-white for the two closest stars — the third appeared ruddy to Webb. Smyth thought they were white, ruddy and bluish. Some observers even called them greenish. Pickering included 12 Lyncis in his 1917 list of the "finest multiple stars" that he observed with his 11-inch refractor.

Now take a look about 7° north of Castor in Gemini. Yes, you're still within Lynx's boundaries. Here you'll find the most distant of the Milky Way's globular clusters — **NGC-2419**. This object was discovered in 1788 by Sir William Herschel and was re-observed in 1833 by his son, John. Lord Rosse published a description of it in 1861 although he couldn't tell for sure what kind of object it was — even with his large scope. In 1922 Lowell Observatory determined it was a globular cluster when it was photographed with the 42-inch reflector. NGC-2419 is a 10.9 magnitude object about 7.2 seconds of arc in diameter. It is located opposite the galactic center, which is very unusual since most of the globulars in our Galaxy lie near the center. The cluster has been called the "intergalactic wanderer" and some early observers thought it was not a member of the Milky Way. Harlow Shapley estimated the distance as 182,000 light-years from the solar system by measuring the brightness of its RR Lyrae variables. This distance is comparable to the Magellanic Clouds. The cluster shows up well in backyard instruments, primarily because of its unusual richness. The brightest individual stars are red and yellow giants more than 360 times brighter than the Sun. Computations suggest that the cluster contains 175,000 stars or more. Try finding this strange object and give it a good scan.

Now move back to Lynx and look at **38 Lyncis** — another double that's easily split. This naked eye "star" is actually a pair of fourth and sixth magnitude suns just three seconds of arc apart. A three-inch refractor at 150 power will resolve the double. Again, some astronomers see the colors differently. Smyth saw them as silvery white and lilac. Webb chose greenish white and blue, but Barns left us with an enigmatic description — "a vivid stellar horseshoe." Was he looking at the right object?

Next, let's check out **NGC-2683** — the only galaxy in Lynx brighter than magnitude 10. This cigar-shaped spiral shines at 9.6 magnitude and measures 8x1 arc-minutes. You can find it just above the group of stars on the Lynx-Cancer border, or by sweeping 1° south and 5° west of Alsciaukat with a low-power eyepiece. Sir William Herschel discovered it — the 200th entry in his list of "bright nebulae." It is brighter than many of its Messier cousins, but does not enjoy the distinction of being a frequently observed object. The *NGC* describes it as "very bright, very large, very much extended in position angle 39 degrees, gradually much brighter in the middle." Webb gives the only classical description calling it a very beautiful object, but scarcely worth the search in his 3.7-inch refractor. If you look in the *NGC* for this object, it will be listed under Leo Minor rather than Lynx! If you do find it, make careful note of its appearance. Modern observational reports of all these obscure objects are needed to fill the gaps in lists made more than a century ago.

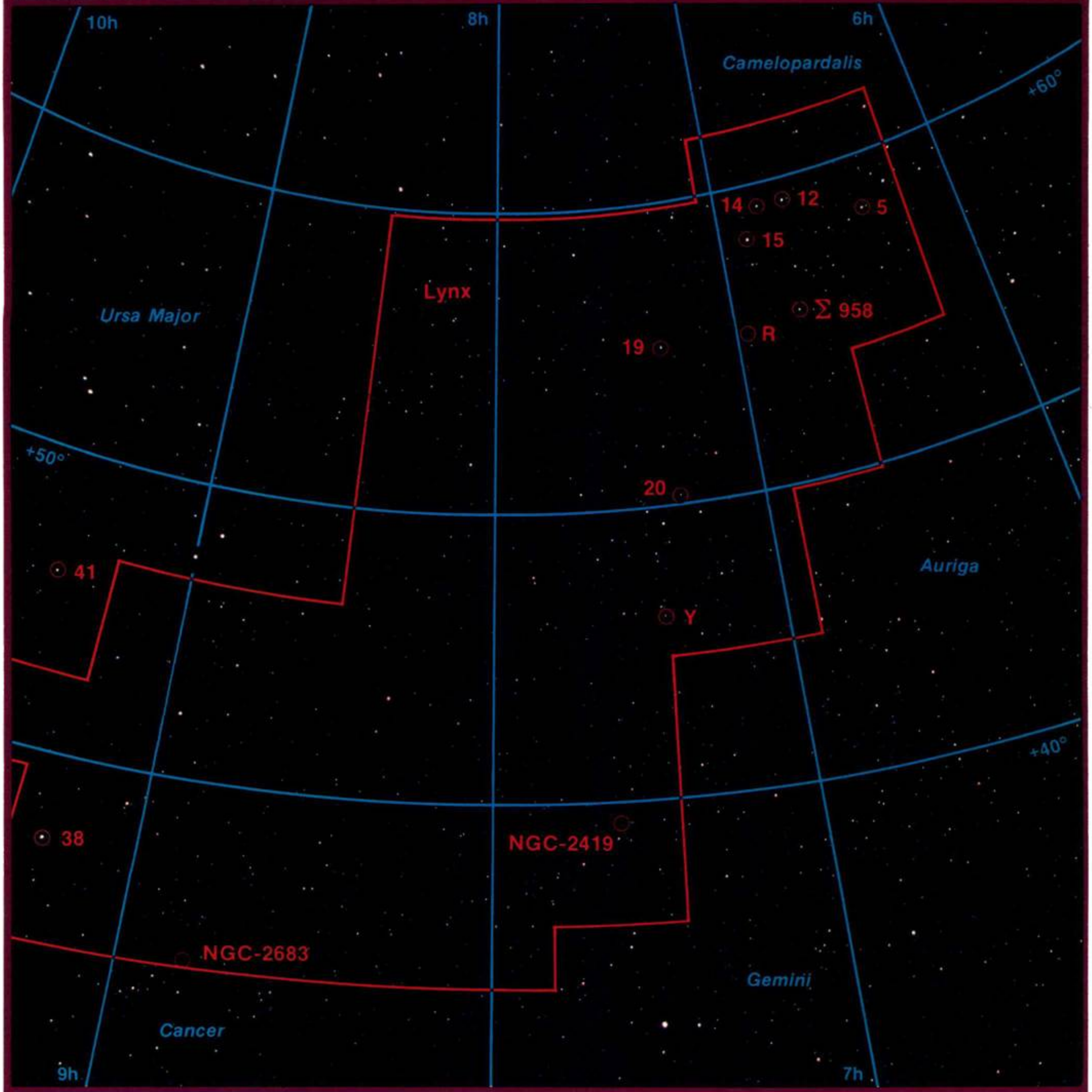
Our last offerings will be stellar, but not double stars. **R** and **Y Lyncis** are two reddish pulsating variables. Y is situated midway between 16 and 25 Lyncis and is the brighter of the two variables easily visible in your finder. It varies in brightness from 6.9 to 7.4 with a period of about 110 days. It has a distinct red hue and is of spectral class M5.

R Lyncis may be a little harder to find depending on what phase it's in when you look for it. It varies between 7th magnitude at its brightest — and 14th magnitude on its down cycle. R is a member of spectral class S and is a Mira Ceti-type star with a deep red hue throughout its entire range. Try finding it — if it's not there, you can bet it is at its minimum.

photo by Brad Wallis & Robert Provin

lynx

map by Robert Burnham


10h
8h
6h
Camelopardalis
+60°
14
12
5
15
Lynx
Ursa Major
Σ 958
R
19
+50°
20
41
Auriga
Y
+40°
38
NGC-2419
NGC-2683
Gemini
Cancer
9h
7h

Object	Type	Mag.	Size/Sep. Per.	R.A. (1950)	Dec.	R.A. (2000)	Dec.
5 Lyncis	★^{2}	5.5,8.2	96″	06h22m	+58°27′	06h27m	+58°25′
12 Lyncis	★^{3}	5.4,6.2,8.0	1.7″,8″	06h42m	+59°30′	06h46m	+59°27′
Struve 958	★^{2}	6.3,6.3	5″	06h44m	+55°46′	06h48m	+55°43′
14 Lyncis	★^{2}	5.9,7.1	0.3″	06h49m	+59°31′	06h53m	+59°27′
15 Lyncis	★^{2}	4.9,6.1	0.9″	06h53m	+58°29′	06h57m	+58°25′
R Lyncis	m★	7.1-12.0	379d	06h57m	+55°24′	07h01m	+55°20′
19 Lyncis	★^{3}	5.6,6.5,8.0	15″,215″	07h19m	+55°23′	07h23m	+55°17′
20 Lyncis	★^{2}	6.6,6.8	15″	07h19m	+50°16′	07h23m	+50°10′
Y Lyncis	∩★	6.9-7.4	110d	07h25m	+46°06′	07h29m	+46°00′
NGC-2419	●	10.9	7.2″	07h35m	+39°00′	07h38m	+38°53′
NGC-2683	§S	9.6	8′x1′	08h50m	+33°38′	08h53m	+33°27′
38 Lyncis	★^{2}	4.0,6.0	3″	09h16m	+37°01′	09h19m	+36°48′
Alpha (α)	★	3.1	—	09h18m	+34°36′	09h21m	+34°24′
41 Lyncis	★^{2}	5.6,7.8	80″	09h25m	+45°49′	09h29m	+45°36′

★	*Star*
★^{2}	*Double Star*
★^{3}	*Triple Star*
m★	*Regular Variable*
∩★	*Irregular Variable*
ꓤ★	*Eclipsing Variable*
○	*Open Cluster*
●	*Globular Cluster*
■	*Planetary Nebula*
□	*Bright Diffuse Nebula*
§0	*Elliptical Galaxy*
§S	*Spiral Galaxy*
§ʃ	*Barred Spiral Galaxy*
§#	*Peculiar/Irregular Galaxy*

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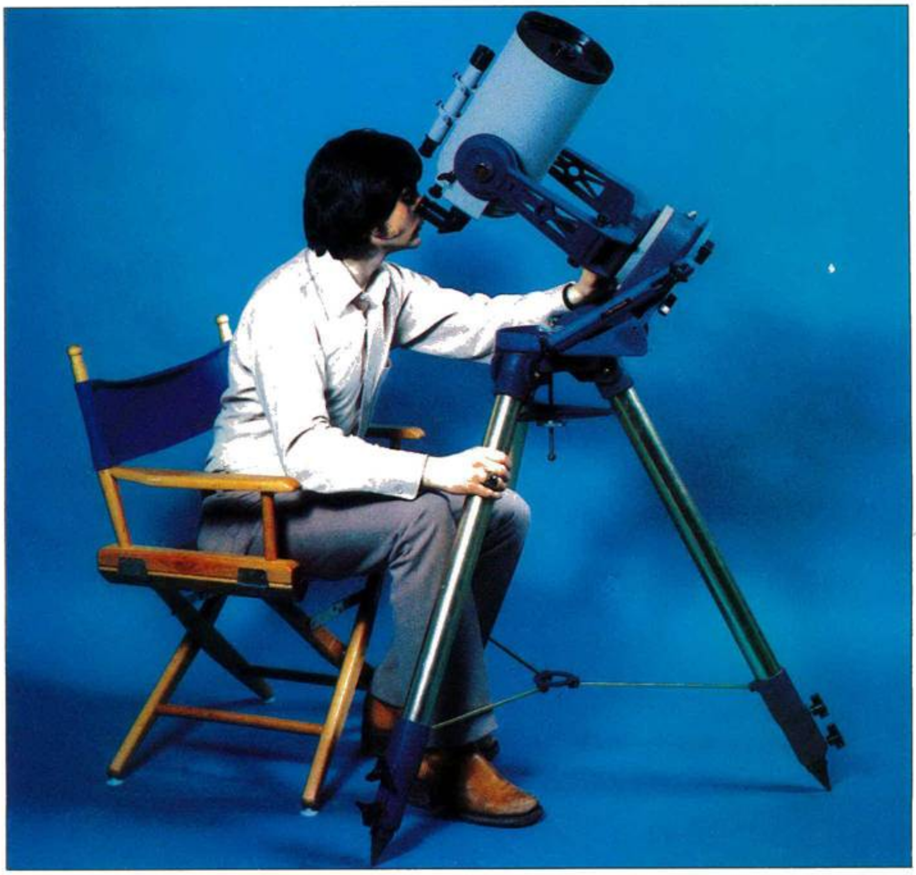

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